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STUDIES ON THE VITALITY OF WHEAT. I. PRO- LONGATION OF VITALITY OF WHEAT SEEDS

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Introduction

"Dormancy"—as a term applied to resting life—has long referred to a state of partially suspended animation, typical, for example, of that in young, air-dried seeds. "Dormancy" has never implied complete passivity, since it is doubtful, in spite of the work and opinion of Brown and Escombe (1898), Giglioli (1895), and others, whether a state of complete passivity is possible in an organism still possessing life. Brown and Escombe held that all chemical activities cease at the temperature of liquid air, that "any considerable internal changes in the protoplasts are rendered impossible at temperatures of -180° to -190° C., and that we must consequently regard the protoplasm in resting seeds as existing in an absolutely inert state devoid of any trace of metabolic activity, and yet conserving the potentiality of life.

. . . And since at such low temperatures metabolic activity is inconceivable, an immortality of the individual protoplasts is conceivable providing that the low temperatures be maintained." Giglioli stated, "It is a common notion that life or capacity for life is always connected with continuous chemical and physical change. . . . The very existence of living matter is supposed to imply change. There is now reason for believing that living matter may exist in a completely passive state without any chemical change whatever, and may, therefore, maintain the special properties for an indefinite time as is the case with mineral and all lifeless matter. Chemical change in living matter means active life, the wear and tear of which necessarily leads to death. Latent life when completely passive in a chemical sense ought to be life without death."

So far as the normal life of seeds is concerned, we certainly have to deal with a progressively perishing quality, and the furthest that we are prepared to go is to agree with Maquenne (1902) that, with desic-

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cation at reasonably low temperatures, seeds are transformed from a condition of diminished activity to a state of suspended life. It is this "suspended life" that we understand by the word "dormancy," a state that, on slightest activation, can be demonstrated by A. D. Waller's (1901) "blaze-current" method without the necessity of having to prove the existence of life by more extreme germination tests.

In recent years, Crocker and his co-workers at the Boyce-Thompson Institute have familiarised us with the use of the word "dormancy" applied specifically to the state of seeds exhibiting a special peculiarity rather than the general characteristics of dormancy; the special peculiarity, studied by these workers, being a tendency to delayed germination, or repressed activity, under conditions of temperature and moisture that are otherwise favourable for germination of the same kind of seeds in their so-called "non-dormant" condition. The recovery from the state of this peculiar form of dormancy of seeds or of their embryos is accomplished in nature, or under artificially imposed conditions (stratification), by an after-ripening at low temperatures in the presence of sufficient water and air; a kind of suppressed activation resulting, which, on removal of the seeds to higher or optima temperatures, brings about immediate or rapid germination of otherwise sluggish seeds. It is, as it were, the difference between a race-horse in the stable and at the starting point, when comparison is made between the dormancy of seeds subject to delayed germination, before and after stratification. This is certainly one example of dormancy, but it does not justify, in our opinion, the use of such an expression as "non-dormant" applied to living seeds or their embryos, even of the same kind, that do not possess this peculiarity. Davis (1930), for example, speaks of "... seeds of *Ambrosia trifida* which have dormant embryos at maturity, and this paper for *Xanthium* seeds which have non-dormant embryos at maturity." As the present papers deal with the dormant life, its retention and activation, of wheat, seeds that do not possess the specific "dormancy," used in the Crocker-sense, or tendency to delayed germination, we do not wish any misconception to arise concerning our use of the word. Moreover, we would not have it argued on any further grounds whatever that wheat seeds are subject to delayed germination just because we have been able, by pre-heating and pre-drying treatments, to speed up germination above the normal under equal external conditions of temperature and moisture during germination.

Crocker (1930) has recently stated, "There is great need of a thorough study of the combined effect of reduced moisture, low temperature and absence of oxygen upon the retention of vitality by stored seeds. It may be that any seeds that withstand moderate artificial drying may have their vitality lengthened many years by the proper com-

bination of these three factors." In the present paper, though we can only partially supply this need, we can confirm to a considerable extent the possibility of prolonging the normal life of seeds, so far as the influence of reduced moisture, oxygen, and light on the retention of vitality in wheat seeds, at any rate, is concerned.

In 1910, after considerable search, we came to the conclusion that, with so many variables among different seeds (such as thickness and permeability of seed-coats, composition, normal life-cycle, etc.) influencing both retention or duration and intensity of life, exhibited by total percentage of germinated seeds on the one hand and speed of germination on the other, it were better to confine the research to one type of seed only. For this work, wheat was chosen. At the same time, in view of the long duration of our proposed observations, we recognised the impossibility, in our case, of being able to subject our seeds to constant, uniform temperature-conditions for twenty years and more, and, for this reason, one of the three important factors in the retention of vitality by seeds was, of necessity, a variable during our experiments.

Longevity

Considering longevity of mature seeds, Becquerel (1906) has reported upon 550 species of seeds representing 30 of the more important families of plants, the seeds having been kept in storage from 25 to 135 years. From these seeds, the oldest that germinated were 80 years old. Of seeds dated 1819 to 1878, eighteen out of ninety varieties of leguminous seeds germinated, three species of *Nelumbium*, one species of *Malvaceae*, and one species of *Labiatae*. The conclusions drawn by Becquerel were that, by age, the thick integument secured a result similar to that obtained by artificial drying, namely, an imperviousness to oxygen and water, and that the thickness of the integument was the governing factor in retention of vitality by seeds.

Nobbe and Hänlein (1880) had previously stated that many cases of delayed germination in seeds were due to the impermeability of the seed-coats to water, and that, when the coats were permeable, the delay was due to some change going on within the embryo during the period of rest. Since that time Kienitz (1880), Winkler (1883), and Wiesner (1897) also have expressed similar views. Arthur (1895), Crocker (1906), and Davis (1930), working principally on *Xanthium* seeds, have now largely cleared up the mystery of delayed germination and have emphasised the importance of an "after-ripening" period in many cases of seeds showing this tendency.

Ewart (1908) has also given results obtained on testing a large variety of seeds ranging from one to sixty years of age, which compare very favourably with those given by Becquerel. Ewart, however, tabu-

lated his results, dividing the seeds into three artificial classes,—Microbiotic (life not exceeding 3 years), Mesobiotic (life from 3–15 years), and Macrobiotic (life from 15 to over 100 years). Carruthers (1911), Duvel (1904), and others have also reported on ancient seeds.

In the case of wheat, we have a normally mesobiotic seed, though, by proper treatment, its life may be prolonged well into the macrobiotic class. The normal life-cycle of wheat is 12 months; it is barely protected by a seed-coat when it falls to the ground in the mature state, and it proceeds to germinate immediately the conditions of moisture and temperature are suitable. A number of further observations have been made on wheat, and we are fairly familiar with most processes operative in its life-cycle. Thus, to quote a few examples, with the authors—we have definite records of the greater efficiency of the seed-coats of oats compared with that of the coats of barley and wheat in protecting the living organism (Theophrastus (Cir. 300 B.C.) and Carruthers (1911)); we have a complete study of the changes taking place from the time of pollination of the wheat flower until the seed is ripe (Brenchley (1909)); we have figures showing respiratory exchange of oxygen and carbon dioxide in wheat seeds under a variety of conditions (White (1909), Becquerel (1906a), Kolkwitz (1901)), and we have definite proof that, whereas wheat seeds will retain their vitality under normal storage conditions for some ten years, though with greatly reduced germinative power (Haberlandt (1875) and Carruthers (1911)), they may, under drier atmospheric conditions, still be germinated to the extent of 2% after 16½ years (White, 1909). We have, further, evidence that wheat seeds, in common with others, keep their vitality longer when the atmosphere is excluded, even by such an inefficient method as enclosure in corked bottles, than when there is freer circulation of air around the seeds such as would exist when the seeds are stored in paper bags (Duvel, 1904); and that low temperatures are conducive to the longevity of seeds (Duvel (1904), Thiselton-Dyer (1899), Brown and Escombe (1898), Giglioli (1895)). Reference should also be made here to the fine study made by Atwood (1914) on the germination of *Avena fatua*, which included a remarkably extensive bibliography of work dealing with germination generally.

So far as longevity of wheat seeds specifically is concerned, the first record is that of Theophrastus (circ. 300 B.C.) who stated, "Also barley perishes sooner than wheat," since barley seeds are naked and wheat is covered with several coats.

Carruthers (1911) differentiated between wheat and barley on the one hand and oats on the other saying, "The difference between wheat and barley on the one hand and oats on the other is the greater protection offered to the embryo of the oat by the fact that, in its case, the

glumes which fall off as chaff in the wheat and barley, remain attached to the seed."

Count Sternberg (1853) was responsible for stirring the public's imagination by recording his results with so-called "mummy wheat," which encouraged the belief that it was possible to grow a crop from wheat dating from about the time that the biblical Joseph lived in Egypt. The myth still lives in popular journals, and other cases of germination of supposed "mummy wheat" are constantly being reported, though it has been proved many times that wheat hardly outlasts ten years, has been known to live 16½ years (now increased to 19 years), and certainly is dead a long time before it is 3,000 years old under ordinary storage conditions. Further reference to mummy wheat can be found in Thiselton-Dyer's exhaustive works on seeds, in E. A. Wallis Budge's letter to "The Times" (1931), and in Whympers work in "Knowledge" (1913).

In 1856-57, Loudet published the following results on wheat of the years 1853-1856:

TABLE I
PERCENTAGE GERMINATION OF SEEDS (1853-1856), RECORDED IN 1856 (LOUDET)

	Percentage of seeds germinated	
Wheat 1853.	0	
Wheat 1854.	51	
Wheat 1855.	73	
Wheat 1856.	74	

In 1861, Haberlandt gave the following figures for seeds including wheat of dates 1850-1860:

TABLE II
PERCENTAGE GERMINATION OF SEEDS (1850-1860), RECORDED IN 1860 (HABERLANDT)

Seeds	Date of seed							
	1850	1851	1854	1855	1857	1858	1859	1860
Wheat	—	—	8	4	73	60	85	96
Rye	—	—	—	—	—	—	48	100
Barley	—	—	24	—	48	33	92	89
Oats	60	?	56	48	72	32	80	96
Maize	—	?	76	56	?	77	100	97

The last recorder of results from old seeds that we shall quote is Carruthers (1911) who examined, each year (between 1896 and 1911), seeds of 1896 harvest, kept under normal conditions of storage, for

percentage germination (Table III). All other figures by other observers confirm the fact that wheat seldom retains its vitality beyond 10 years under normal storage conditions.

TABLE III
PERCENTAGE GERMINATION OF SEEDS DATED 1896, RECORDED EACH YEAR 1896-1911
(CARRUTHERS)

Seeds	Year of germination test of seeds of date 1896															
	1896	1897	1898	1899	1900	1901	1902	1903	1904	1905	1906	1907	1908	1909	1910	1911
Barley	99	99	98	95	90	77	25	?	19	—	—	—	—	—	—	—
White wheat	100	97	92	94	?	88	75	?	29	—	—	—	—	—	—	—
Red wheat	99	98	95	88	94	80	79	55	51	—	—	—	—	—	—	—
White oats	100	99	99	99	98	99	99	95	97	69	57	49	12	—	—	—
Black oats	97	97	96	94	90	98	92	94	95	88	76	68	34	32	2	—

White (1909) has, however, put on record the case of a South Australian wheat that, after 16½ years, germinated to the extent of 2%. This is the oldest *authentic* living wheat on published record up to the time of the present experiments that the authors have been able to find.

Experimental

With such of these facts as had been published in 1911 taken into consideration, the present writers took a number of tubes made of specially hard glass, and selected a large sample of Rivet wheat of that year's harvest for their experiments, each experiment being made in triplicate, one tube of each of which was stored in the light, the remainder in the dark. The wheat was placed in the tubes under a variety of conditions, reasonable and unreasonable, and the tubes in turn were placed in a strong mahogany cabinet fitted with a window of plate-glass on top to allow entry of light to one series of the experimental tubes.

Seeing that the War and its subsequent stress interrupted observations until 1923, it is not surprising that nearly all our results were negative, but the one outstanding positive result makes up for the failure of others. The negative results were obtained with wheat treated as follows: Control tubes with open end, wheat stored in light and dark; wheat sealed in tubes at atmospheric pressure, stored in light and dark; wheat sealed with 20% added water; wheat treated with 140% of its weight of water for 2 days and subsequently sealed; wheat sealed in tubes after evacuation of air; wheat with approximately 10% chloroform not in contact with seeds, and sealed; wheat covered with ether solution of bitumen, dried and subsequently sealed; wheat sealed in atmosphere as completely deprived of oxygen as possible; wheat sealed

in tubes containing about 20% formaldehyde absorbed on cotton; wheat sealed with 15% of water absorbed into the seeds; wheat embedded in blocks of paraffin wax, with and without added water previously soaked up by the seeds; wheat sealed up after soaking in hydrogen peroxide; wheat sealed in atmosphere of sulphur dioxide; wheat sealed in atmosphere of oxygen; wheat sealed after soaking in 20% solution of ammonium hydroxide; wheat immersed in peanut oil and sealed; wheat sealed in an atmosphere of coal gas; wheat sealed in tubes containing cotton soaked with 90% alcohol.

All these experiments gave negative results when attempts were made to germinate the seeds in May, 1927 (*i.e.*, after 15½ years).

The only positive result was with the wheat placed in tubes with dry, fused calcium chloride, prevented from coming into contact with the seeds by plugs of cotton. Further samples of the seeds were submitted to Rothamsted Experimental Station, upon which Dr. Winifred Brenchley reported as follows: "All the seeds proved to be dead and failed to germinate, except some of those sealed up with calcium chloride, and those which had been kept in a desiccator for 13 months before sealing (see later experiments). These two gave a germinative capacity of 12% and 89% respectively after 14 days. Further notes made during the course of the test are appended." It is not intended here to give the analytical data, measurements of the seeds, atmospheric conditions at time of sealing, and method practised for sealing and for the subsequent tests for germination. The following tables will probably supply all the necessary information regarding the successful experiments.

TABLE IV

SAMPLE OF 1911 ENGLISH RIVET WHEAT SEALED IN TUBES IN THE PRESENCE OF, BUT NOT IN CONTACT WITH, DRY FUSED CALCIUM CHLORIDE (WHYMPER AND BRADLEY)

Sample number	Date of germination	Age	Moisture in seeds at time of germination experiments		Germination	Remarks
			P.ct.	P.ct.		
1	Oct. 7, 1911	1 month	10.32	95		Rivet wheat from Huntingdon, Eng.; germination complete in 6 days.
2	May 13, 1927	15 years 7 months	4.60	12		Germination complete in 14 days.

TABLE V
EFFECT OF DESICCATION ON ONE SAMPLE OF ENGLISH RIVET WHEAT (1911) ON LONGEVITY AND POWER OF GERMINATION
(WHYMPER AND BRADLEY)

Experiment	Date of germination	Total age from harvest	Time in desiccator over calcium chloride	Moisture in seeds at date of germination	Germination	Remarks
3	Sept. 1911	0	0	<i>P.ct.</i> 16.00	<i>P.ct.</i> 98	<i>cf.</i> Experiment 10.
4	May 3, 1913	1 year 8 months	0	?	95	In desiccator in light.
5	May 7, 1913	1 year 8 months	4 days	7.60		In desiccator in light.
6	May 3, 1913	1 year 9 months	35 days	3.50		In desiccator in light.
7	June 24, 1913	1 year 9 months	56 days	1.76		In desiccator in light.
8	Oct. 10, 1913	2 years 1 month	164 days	0.66	100	In desiccator in light. Germination complete in 24 hours.
9	June 22, 1927	15 years 9 months	164 days	0.66	82	Wheat from Experiment 6 sealed up in glass tube after removal from desiccator on Oct. 10, 1913. Germination was fairly normal <i>i.e.</i> 3% in 24 hours, 42% in 48 hours, 72% in 71 hours, and 82% in 120 hours.
10	June 22, 1927	15 years 9 months	0	?	0	The original wheat from Experiment 3 kept in tubes both sealed and open in dark and light failed to germinate after 15 years and 9 months.

TABLE VI
EFFECT OF DESICCATION ON ONE SAMPLE OF ENGLISH SQUARE HEADS MASTER WHEAT (1913) ON LONGEVITY AND POWER OF GERMINATION (WHYMPER AND BRADLEY)

Experiment	Date of germination	Total age from harvest	Time in desiccator over calcium chloride	Moisture in seeds at date of germination	Germination	Remarks
11	Nov. 6, 1913	2 months	0	<i>P. ct.</i> 13.20	<i>P. ct.</i> 92	In desiccator in light.
12	Oct. 15, 1913	1 month	3 days	6.70	93	In desiccator in light.
13	Mar. 7, 1914	6 months	146 days	5.31	92	In desiccator in light.
14	Oct. 15, 1914	1 year 1 month	368 days	4.10	91	In desiccator in light.
15	Oct. 15, 1923	10 years 1 month	3653 days	1.97	62	Wheat from Experiment 14 taken from desiccator after 368 days and sealed up in glass tube Oct. 15, 1914, and stored in dark.
16	Mar. 9, 1927	13 years 6 months	368 days	4.38	83	Tested at Rothamsted Experimental Station.
17	May 13, 1927	13 years 8 months	368 days	4.38 (?)	89	Continuation of Experiment 16.
18	Jan. 4, 1930	16 years 4 months	368 days	4.41	84	Continuation of Experiment 16.
19	Aug. 29, 1931	17 years 11 months	368 days	4.38 (?)	83	Continuation of Experiment 16. (Germination 24% in 48 hours; 41% in 71 hours; 82% in 106 hours; 83% in 130 hours).
20	Aug. 12, 1932	18 years 11 months	368 days	4.38 (?)	83	

Conclusions

Desiccation over calcium chloride is conducive to retention of vitality in wheat. It appears that it is preferable, in order to secure long retention of vitality, to dry the wheat in a desiccator (*a*) in the dark, or (*b*) in the light for a period of time, and, subsequently, to remove the wheat from the desiccator and to store in the dark in sealed containers.

There are indications that either our observations with Rivet wheat on the one hand and Square Heads Master on the other are not comparable, or that the method, degree and speed of drying, even in a desiccator, influence longevity, and that whether the seeds are stored in light or dark is an important factor in determining retention of life. Thus in the case of Square Heads Master, desiccation to 4.10% of moisture over a period of 368 days in the light, and a subsequent sealing and storage in the dark, are more effective processes in preserving vitality up to 19 years, than is drying in a desiccator in the light to 1.97% moisture for 3653 days in preserving vitality for 10 years, as shown by the germination powers 83% and 62% respectively in the two cases. In the case of Rivet wheat, desiccation was apparently more rapid, a moisture-content of 0.66% being reached in 164 days in a desiccator over calcium chloride, the drier wheat showing an increased germinative power at the total age of 2 years. The highly desiccated Rivet wheat sealed up in a glass tube and stored in the dark still showed a germinative power of 82% at the end of a total age of 15 years 9 months.

From experiments in which access of air or oxygen to the seeds was prevented by covering the seeds in wax, immersion in oil, or by sealing the seeds in an atmosphere free from oxygen, it appears that cessation of respiratory exchange is destructive to vitality, whereas appreciable restriction of respiration by desiccation is conducive to longevity. The probability of formation of toxic substances within the seed-embryo by preventing gaseous exchange should not be overlooked, while it is still undetermined whether the absence of oxygen or the accumulation of carbon dioxide, or both, is the real cause of death.

In the case of desiccation of wheat seeds, the seed-coats of which are not rendered appreciably impervious to gases by drying—as is the case with many seeds—the effect of reducing the moisture by desiccation in prolonging life is doubtless due to slowing-down of intracellular reactions only.

At the present rate of determination, the life of wheat may, under the conditions of one of our experiments, be estimated at approximately 50 years. Hitherto 16½ years with 2% germination has been the oldest living wheat recorded by reliable authorities. One of our experiments shows a wheat 18 years 11 months old with an 83% germination. *i.e.*,

after the wheat had been sufficiently desiccated and subsequently stored in the dark in sealed tubes.

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REPORT OF THE 1933-34 COMMITTEE ON THE STANDARDIZATION OF LABORATORY BAKING

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(Presented at the Annual Meeting, June, 1934)

The Committee on the Standardization of Laboratory Baking appointed by the president for the past year consisted of M. J. Blish, R. T. Bohn, D. A. Coleman, C. N. Frey, R. K. Larmour, G. Moen, J. W. Whitacre, E. B. Working, and W. F. Geddes. Owing to pressure of his regular duties, Mr. Whitacre found it necessary to resign and T. R. Aitken was appointed in his stead.

As was the case last year, the distances separating the individual members made it impractical to hold any meetings to discuss plans regarding the work to be undertaken but, by means of correspondence, a fairly extensive program was agreed upon which has been carried out by the members and their associates in their own laboratories without expense to the Association. It is rather significant that every member of the Committee has contributed either directly or indirectly subcommittee reports on some particular phase of the experimental baking test, and as a result of this whole-hearted cooperation, the work of the chairman has been considerably lightened. Under this arrangement the subcommittee reports of the individual members represent the collective activities of the Committee. In view of expressions of opinion at the 1933 convention that more attention should be given to the devel-

opment of supplementary procedures and their interpretation, major emphasis has been placed on this line of activity, although some consideration has been given to the mechanization of the baking test procedure. From the studies reported, it would appear that the accepted interpretations of the behaviour of flours to various supplementary procedures are sometimes fallacious and an interesting field for further work is indicated.

In addition to specific experimental studies, a questionnaire was circulated to a large number of the members of the Association resident in America, for the purpose of obtaining information as to the baking methods in general use and the value of the basic and supplementary procedures. The thanks of the Committee are extended to all those who participated in this survey by submitting replies. The present questionnaire has revealed that there is less variability in baking methods now in use than indicated by the questionnaire circulated in April prior to the official adoption of the basic procedure. While many of the laboratories employ some form of "pup loaf" baking test, few, however, use the basic procedure exactly as specified and approved by the Association. It was almost universal opinion that fixed absorption and hand mixing should be abolished, and variable absorption and machine mixing incorporated in the specifications for the standard procedure. While the Hobart-Swanson mixer was approved by the Association in 1933, the outline of the basic baking test has not been revised to incorporate this and other changes which would appear desirable as a result of the work of the Baking Test Committees during the past several years. It therefore seemed advisable to prepare a new outline embodying desirable changes, especially in view of the fact that the Committee on Methods is preparing a revised edition of the Book of Methods in which it is planned to detail the standard basic experimental baking test. In this connection the cooperation of the Baking Test Committee was requested and a revised outline has been prepared which is detailed in the following report of the Baking Test Committee. The major changes which have been incorporated are indicated below:

I. Equipment

(a) Fermentation Bowls

Graniteware oatmeal bowls, having the following inside dimensions: top diameter 14.5 cm., bottom diameter 5 cm., and depth 6.5 cm., be substituted for similar bowls with corresponding measurements of 12.5, 5, and 5.5 cm.

(b) Baking Pans

1. To be constructed of 2XX tin rather than spotless metal.

2. Both tall and low form tins may be employed—the low form tins being of the following inside dimensions:

Length—top	11.5 cm.	bottom	9.5 cm.
Width — “	7.0 “	“	5.5 “
Depth —	5.0 “		

The low form tins are especially recommended for research work. In reporting results, the type of pan employed should be specified.

II. Basic Formula

Variable rather than fixed absorption is specified.

III. Baking Procedure

(a) Mixing

The Hobart-Swanson mixer with a mixing time of one minute is specified. Where the official mixer is not available any method of mixing may be employed which will thoroughly incorporate the ingredients and produce a smooth dough with a minimum of gluten development. For this purpose the Hobart mixer (equipped with 2 dough arms or a cake paddle), or hand mixing, are suggested, but hand mixing is not favoured.

(b) Moulding

The outline calls for the moulding of the dough on cotton or canvas belting rather than on a moulding board.

Recommendations of the Committee

1. That the revised outline of the standard basic baking test as detailed in the accompanying report be officially adopted by the Association.
2. Since the test as outlined is essentially for hard wheat flours, it is recommended that the 1934-35 Committee undertake the development of specifications as regards mixing and fermentation times for soft wheat flours.

OFFICIAL A. A. C. C. BASIC BAKING TEST

(Prepared by 1933-34 Committee on Standardization of Laboratory Baking, W. F. Geddes,¹ *Chairman*)

(Presented at the Annual Meeting, June, 1934)

Equipment

(1) Mixer:—Hobart-Swanson (Hobart Manufacturing Company, Troy, Ohio, U. S. A.).

(2) Fermentation Bowls:—Graniteware "oatmeal bowl." Top diameter 14.5 cm., bottom diameter 5 cm., and depth 6.5 cm., all inside dimensions.

(3) Fermentation Cabinet:—Cabinets similar to those described in Cereal Chemistry, 7: 341, or 8: 233, capable of accurate temperature control ($\pm 0.5^\circ$ C.) and of maintaining a relative humidity of at least 75%, are satisfactory.

(4) Baking Pans:—Constructed of 2XX tin; tall or low form tins with the following inside dimensions may be employed.²

<i>Low form tins</i>				<i>Tall form tins</i>			
Length—top	11.5 cm.	bottom	9.5 cm.	Top	10.5 cm.	bottom	9.3 cm.
Width—	7.0 "	"	5.5 "	"	6.0 "	"	5.3 "
Depth	5.0 cm.			Ends—	6.8 "		
				Sides—	8.5 "		

(5) Baking Oven:—Capable of maintaining a temperature of 230° C. ($\pm 5^\circ$) preferably equipped with rotating plate upon which the pans are placed.

(6) Thermometers:

(a) Fermentation cabinet and dough testing—A. A. C. C. official thermometer graduated from 15° C. to 40° C. or equivalent Fahrenheit range.

(b) Oven—A. A. C. C. official thermometer graduated from 100° C. to 260° C. or equivalent Fahrenheit range.

(7) Volume measuring apparatus:—An apparatus similar to that described in Cereal Chemistry 7: 307 is satisfactory. The apparatus should be accurately calibrated. For this purpose a set of aluminum loaf models (Cereal Chem. 7: 346) is convenient. It is suggested that

¹ Chemist in Charge, Dominion Grain Research Laboratory, Board of Grain Commissioners, Winnipeg, Canada.

² Investigation has shown that the low form tins give significantly higher volumes, lower variability between replicates, and more uniform crumb grain and texture than the tall form tins; also they correspond more closely to commercial pans. The low form tins are especially recommended for research work. In reporting results of baking tests, the type of pan employed should be specified.

four standards of approximately 300, 400, 500, and 600 cc. be employed. By plotting these against the loaf volume readings of the measuring device, the calibration curve of the apparatus is obtained.

Preparation of Salt-Sugar Solution and Yeast Suspension (Cereal Chem. 5: 470)

As the absorption of flours exceeds 50%, it is convenient to prepare a stock solution of sugar and salt and a yeast suspension of such a strength that 25 cc. of each contains the required quantities of these ingredients per loaf.

The volume displacement of 3 gms. fresh compressed yeast is 2.5 cc., and that of 1 gm. salt and 2.5 gms. sugar when dissolved together to make a total volume of 25 cc., is 1.86 cc.

The quantities of yeast, salt and sugar and water required to prepare solutions for varying numbers of loaves are shown below:

TABLE FOR PREPARING YEAST-SUSPENSION AND SALT-SUGAR SOLUTION REQUIRED FOR SPECIFIED NUMBERS OF LOAVES, USING 25 CC. EACH PER LOAF

Number of loaves	Yeast suspension		Salt—sugar solution		
	Yeast	Water (distilled)	Sugar	Salt	Water (distilled)
	grams	Cc.	grams	grams	Cc.
5	15	112.5	12.5	5.0	115.7
10	30	225.0	25.0	10.0	231.4
15	45	337.5	37.5	15.0	347.1
20	60	450.0	50.0	20.0	462.8
25	75	562.5	62.5	25.0	578.5
30	90	675.0	75.0	30.0	694.2

Water added per loaf in form of stock solutions:

- | | |
|-------------------------|------------|
| (1) Yeast suspension | = 22.5 cc. |
| (2) Salt-sugar solution | = 23.1 cc. |

Allowance in computing absorption 45.6 cc.

The yeast suspension must be agitated before and during the removal of an aliquot.

The solutions should be kept at such a temperature that, when mixed with the flour and any extra water required, the doughs will come from the mixer at 30° C. ($\pm 0.5^\circ$ C.).

A convenient method of dispensing the water-yeast suspension and salt-sugar solution is given in Cereal Chemistry, 10: 367.

Basic Formula

Flour— 100.0 ± 0.1 gms. on 15% moisture basis (85.0 gms. dry matter). Moisture to be determined by 130° C. air oven or vacuum oven method.

Yeast—3.0 gms. (3%) fresh compressed yeast.

Salt—1.0 gm. (1%) 99.5% pure.

Sugar (Sucrose)—2.5 gms. (2.5%).

Water—Distilled—sufficient to yield dough of standard consistency. The dough should not be mixed too "tight" or too "slack."

Standard Procedure

1. Mixing

(a) Place the flour in the bowl of the Hobart-Swanson mixer, add 25 cc. each of the yeast suspension and salt-sugar solution plus sufficient additional distilled water to bring the dough to the desired consistency. (If this is not accomplished before the dough has formed, the mix should be discarded and the test repeated.) Mix for one minute. The doughs should come from the mixer at a temperature of 30° C. ($\pm 0.5^\circ$ C.). Should it be found that 100 grams of flour yields too small a dough for thorough mixing, a larger quantity may be used and the dough scaled to proper weight after mixing.

(b) Alternative Procedures:

Where the official mixer is not available, any method of mixing may be employed which will thoroughly incorporate the ingredients and produce a smooth dough with a minimum of gluten development. For this purpose the Hobart mixer equipped with 2 dough arms or cake paddle, or hand mixing are suggested. Hand mixing should only be resorted to when a machine mixer is not available, the procedure for which is outlined in Cereal Chemistry, 5: 158-161.

2. Calculation of absorption

% absorption (15% moisture basis) = $45.6 + W - (100 - F)$
where W = cc. additional distilled water added and F the weight of flour taken.

3. Fermentation—First punch after	105 minutes
Second punch after additional	50 "
Mould after additional	25 "
	<hr/>
Total	180 minutes

Remove dough from mixing bowl, fold 20 times in the hands, round up, put in fermentation bowl, and place in fermentation cabinet. After 105 minutes remove dough from bowl and fold 15 times in the hands; round up, return dough to bowl and cabinet. Give second punch after

an additional 50 minutes' fermentation, folding the dough ten times and rounding up as before. After a further 25 minutes' fermentation the dough is moulded and panned as outlined below.

4. *Moulding and panning.* The dough is moulded on a piece of cotton or canvas belting. Place dough on the belting and press with the heel of hand until the dough is uniformly flat and circular as shown by example 1, Figure 1. Loosen dough from the belting and turn on re-

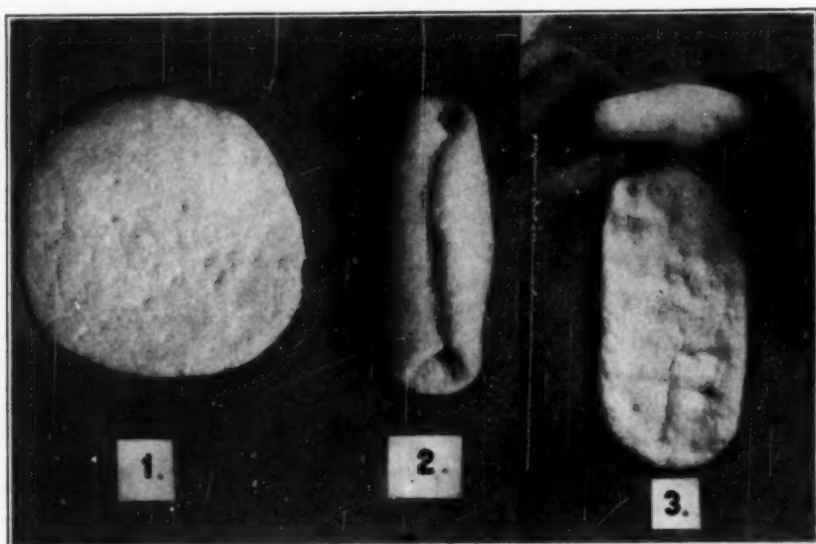


Figure 1.

verse side. Fold over two opposite sides so that they overlap to a considerable degree—example 2, Figure 1. Turn dough over and again flatten with heel of hand. Holding one end, again loosen from moulding surface and turn on reverse side with seam of dough running away from operator. Starting at the more remote end, roll toward operator, folding as tightly as possible—example 3, Figure 1. Seal the seam tightly and with seam on the bottom, seal ends by punching them vertically. Roll lightly under palm of hand, adjusting dough to length of pan and place in pan with seam down. The length of dough should not exceed that of the pan prior to the final light rolling. *No dusting flour is used in the molding process.* Pans may be very lightly greased only when absolutely necessary to prevent the loaves from sticking to the sides of the pan.

5. *Proving.* Proof 55 minutes under same conditions as used for fermentation.

6. *Baking.* Bake 25 minutes at a temperature of $230^{\circ}\text{C.} (\pm 5^{\circ}\text{C.})$ at the level of the top of the baking pan and 5 cm. distant therefrom on the side next the axis of rotation. Precise control of temperature is essential. An open pan of water should be placed in the baking oven.

7. *Measurement.* Weigh the loaf and measure its volume 30 minutes after removal from the oven. Place the loaves in a fairly air tight cabinet until the following morning.

8. *Scoring.* The loaves are scored the day following baking for the external characteristics, crust colour and symmetry, and for the internal characteristics, crumb colour, grain and texture. Helpful suggestions for classifying and scoring loaves are given in Cereal Chemistry, 5: 277, 6: 164, 6: 253, 10: 545.

Discussion

The basic formula and standard baking procedure as outlined above are designed primarily for hard wheat flours to serve as a point of reference and a basis for any supplementary tests that may be considered appropriate. Any additional testing procedure designed to reveal particular characteristics of flours may be employed but only one variable at a time should be introduced. Such tests as mechanical modification by varying the mixing time, the addition of diastatic supplements, oxidizing agents as potassium bromate, and the use of varying fermentation times have been found particularly valuable.

Fresh bakers' yeast from the same source should be used in any one investigation, and the supply stored in the ice box in containers to prevent evaporation of moisture. The outside portions of the yeast cake should be removed before using. Studies on the effect of aging yeast on loaf volume are somewhat contradictory and it is advisable to secure a fresh supply every two days (Can. J. Research 6: 614, Cereal Chem. 10: 617).

It is advisable to prepare five "dummy" doughs at the beginning and end of each regular day's baking, in order to provide more uniform oven conditions at the beginning and end of the series.

Selected References to Literature on Experimental Baking

Cereal Chem. 2: 232, 310, 3: 65, 216, 252, 4: 149, 291, 299, 436, 5: 146, 158, 208, 215, 220, 277, 366, 375, 470, 6: 60, 70, 164, 196, 249, 253, 338, 414, 506, 7: 307, 322, 331, 340, 341, 346, 348, 8: 63, 64, 95, 233, 265, 267, 293, 300, 381, 9: 175, 404, 10: 1, 30, 140, 330, 367, 437, 521, 531, 533, 545, 547, 555, 560, 585, 588, 593, 601, 605, 612, 617

YEAST VARIABILITY AND ITS CONTROL IN FLOUR GASSING POWER TESTS^{1, 2}

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(Presented at the Annual Meeting, June, 1934)

Introduction

That there is a high positive correlation between diastatic activity and "gassing power" in wheat flours is well known to cereal technologists. The correlation is not absolute, however, and in the strict sense the two properties are not identical. It was shown by Blish, Sandstedt, and Astleford (1932) that the lack of absolute parallelism between diastatic activity and gassing power can in a large measure be accounted for by variations among flours with respect to original sucrose content.

It is probable that the correlation between diastatic activity and gassing power is so highly positive that the quantitative estimation of either property can in most situations be made to serve the purposes of technological control in flour and bread production. What the technician wants, of course, is an accurate measure of a flour's ability to maintain gas production during dough fermentation. Theoretically, the gassing power test should give the more complete picture. Practically, however, one must also consider the reliability and accuracy of the test itself, as well as other features, among which are the convenience and simplicity of the method, and the time consumed. The skill, customs, and personal preferences of the operator are additional factors of importance.

In measurements of diastatic properties, we are dealing only with certain biochemical processes occurring within the flour itself, and with adequate control of all environmental conditions the flour alone should be the only important variable, excluding bacterial activity which probably is not a serious factor in modern methods for the estimation of diastatic activity. In the determination of gassing power, on the other hand, the situation is complicated by the addition of yeast. Yeast, a living organism, is not a substance having fixed and constant properties.

Numerous methods have been devised and proposed for the estimation of comparative gassing powers of flours and of yeasts. The

¹ Subcommittee report, 1933-34 Committee on the Standardization of Laboratory Baking.

² Published with the approval of the Director as Paper No. 152, Journal Series, Nebraska Agricultural Experiment Station.

manometric method used by Blish, Sandstedt, and Astleford (1932) for studying comparative gassing powers of wheat flours was suggested by an investigation of vegetable amylases by Schultz and Landis (1932). They used a large quantity of yeast "to ferment out the sugars as rapidly as they are formed," and, at appropriate intervals, they measured volumetrically the quantities of CO_2 given off.

Blish, Sandstedt, and Astleford (1932), in applying the foregoing principle to a simple manometric procedure, used 15 gms. of yeast to 3 gms. of flour in a water suspension, on the theory that with such a large yeast excess the maltose produced by diastatic activity should be fermented out as fast as it was formed, and that it should thereby be possible to eliminate any factor of yeast variability.

For a period of several weeks, the experimental results appeared to uphold the theory, but later, in warmer weather, discordant results occasionally appeared, and these discordant values were generally lower than the former values. Efforts to discover and eliminate the cause of the difficulty, while still retaining the basic principles of the method, were unsuccessful, and it became necessary to recommend that a standard flour be run with each series of tests for the purpose of introducing a correction factor when necessary.

Subsequent to the work of Blish, Sandstedt, and Astleford (1932), several methods for estimating the amount of gas produced during yeast fermentation have been proposed, among which are the methods of Markley and Bailey (1932), Heald (1932), Schultz and Kirby (1933), Elion (1933), Brabender (1933), and Landis (1934). The method of Landis (1934) is comparable to that used by Blish, Sandstedt, and Astleford (1932) in simplicity and compactness of the apparatus used. His apparatus is merely a pint fruit jar whose lid is fitted with a Hoke-Phoenix pressure gauge. Buffered dough or bread extracts (or sugar solutions) are used in conjunction with a large quantity of yeast.

The manometric method offers the following advantages over most other types of methods: Simplicity of apparatus, economy both of equipment and of space, compactness, and minimum of difficulty in temperature control.

Object of Investigation

This communication is concerned with experiments undertaken for the purpose of eliminating certain objectionable features of the method previously reported by Blish, Sandstedt, and Astleford (1932). The main objective has been to minimize the factor of yeast variability. Substantial improvements in the manometric apparatus have been effected.

Experimental

Preliminary studies were made in which small quantities of dough were used instead of the flour-yeast-water suspensions. The doughs contained only flour, water, and yeast. 10 gms. of flour were doughed with 7 cc. of water containing the yeast in suspension, using a stiff spatula, and the ball of dough was then introduced into the Erlenmeyer flask, which was fitted with a mercury manometer, and placed in the 30° C. water bath.

Using 3% of yeast (0.3 gm. per 10 gms. of flour), which is the same yeast percentage as is used in the A. A. C. C. experimental baking test, yeast variability appeared to be practically negligible, as indicated by results in different days, and with different lots of bakers' yeast. This was in contrast to the experience encountered when the same yeasts were used in the method reported by Blish, Sandstedt and Astleford (1932), involving a large yeast excess in water suspension. The dough method also has the distinct advantage that no shaking is required, whereas in the suspension method, time, frequency, and amount of shaking are all factors which influence results. This situation therefore removes a factor of variability, while at the same time it affords added convenience and time-saving in manipulation.

The dough method using 3% of yeast has one feature that some might find objectionable. This is the length of time required for gassing power determinations. With average bakers' flours a duration of 4 or 5 hours is necessary for securing satisfactory comparative values, which are expressed as millimeters of mercury. However, no attention by the technician is required, aside from hourly readings of the manometers, and this element of convenience compensates largely for the time element. Furthermore, this method provides conditions closely comparable to those found in actual bread-making.

Improved Apparatus

The preliminary trials having indicated the basis for a gassing power method of exceptional simplicity and reliability, efforts were directed toward establishing a more convenient and standardized manometric equipment which could be built at low cost. After numerous trials and failures, the equipment shown in Figures 1 and 2 was found to constitute a substantial improvement over the Erlenmeyer flask apparatus originally used.

The equipment shown in Figures 1 and 2 is constructed from half-pint "Ball Perfect Mason" jars, and "Kerr Mason" caps. The caps are in two pieces: a flat circular lid which contacts the rim of the jar, and a threaded collar-band which is screwed down tightly on the lid.

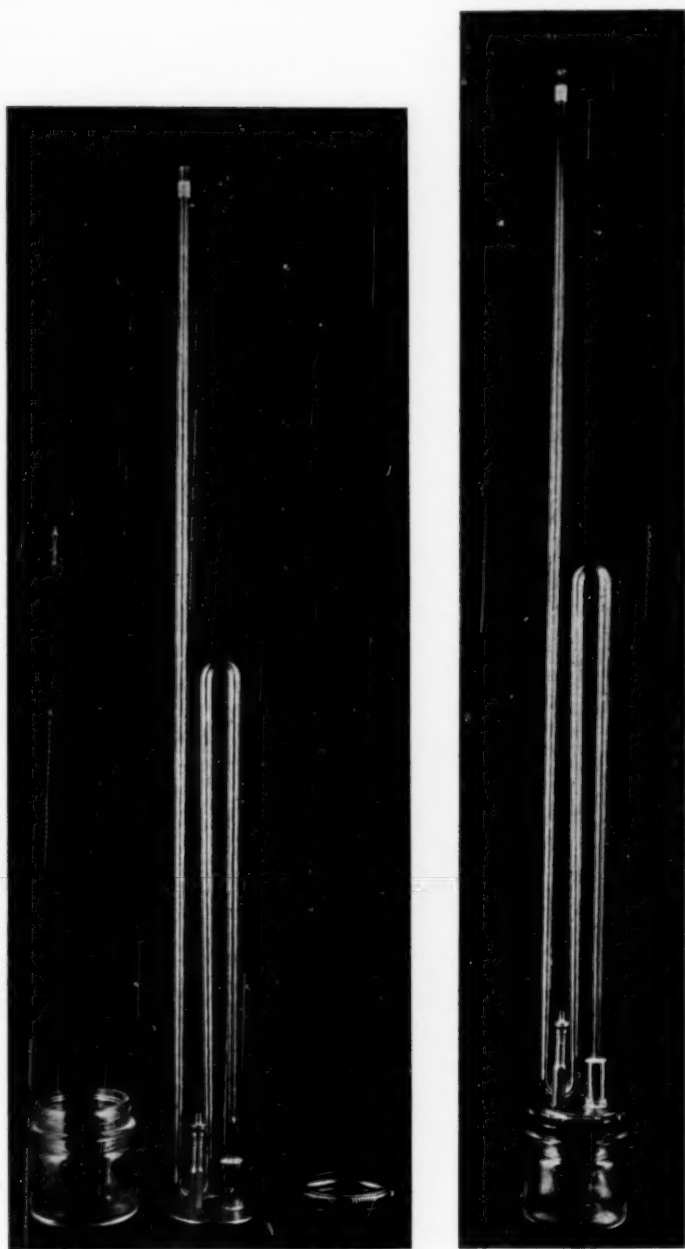


Fig. 1. Individual parts of the gasometer.

Fig. 2. Gasometer assembled, but without test material.

A rubber-like sealing composition on the under rim of the circular lid permits a gas-tight seal. The jars are of 250 cc. capacity and are of surprising uniformity in volume. They should be calibrated with water, and an occasional one which does not conform to the majority should be discarded.

A piece of brass tubing about 13 mm. internal diameter and about 3.5 cm. long is soldered to the upper side of the lid to serve as a sleeve into which the manometer is fitted with a piece of smooth, live rubber tubing. The barometer glass tubing used for the manometer, and the piece of rubber tubing should be selected for size so that a little pressure is required in pushing the manometer and rubber tubing into the sleeve. The rubber tubing should be given a coating of shellac just before fitting it into the brass sleeve. These precautions will in nearly all cases insure a permanent connection that will resist enormous gas pressure without leaking.

The lid is also fitted with an ordinary automobile-tire or bicycle-tire valve, for releasing pressure wherever necessary. In putting on the cap it is usually necessary to tighten the screw band with a strap wrench or a fruit-jar wrench. Occasionally screw bands will jump the threads when tightened with the wrench. Such bands are discarded and new ones used. They are so cheap that a large supply may be kept on hand. Bands may be strengthened by twisting baling wire tightly around them.

After continued use, the sealing compound that serves as a gasket on the under rim of the lid becomes worn through. New gaskets can be made by applying some vulcanized latex³ of proper consistency, and allowing to stand a day or so. These gaskets last longer than the original ones.

The apparatus may be tested for leaks by pumping it up with a bicycle pump and putting it under water.

Adopted Procedure

Using the equipment shown in Figures 1 and 2, the procedure is to mix the 10 gms. of flour with 7 cc. of water containing 0.3 gm. of yeast in suspension with a spatula in the pressure jar which has previously been warmed to 30° C. The manometer is then screwed on tightly, and the apparatus is placed in the 30° C. water bath, using a lead collar to hold it down. After 5 minutes—for allowing the entire system to come to temperature—the manometer is adjusted to zero by opening the valve for an instant, and the time is noted. All later readings are taken with reference to this initial time. *In reading the manometer at*

³ "Vultex"—a product made by the Vultex Chemical Co., Cambridge, Mass. Grade F-106-1 is used. It should be thickened to a putty-like consistency by heating on a steam bath with constant stirring.

any time the total distance from one end of the mercury to the other (in millimeters) is measured and recorded. It is not advisable merely to read from the zero point to *one* end of the mercury, and multiply the result by two, because the bore of any piece of barometer tubing is likely to be lacking in uniformity, and this was found to cause a systematic error in several instances, using the latter method of measurement.

Yeast Variability Observations

Using the above-described procedure, the factor of yeast variability was studied over a period of approximately 4 months. This study consisted essentially of making repeated observations, using the same flour at all times with yeasts of different lots, different ages, and (to a very limited extent) different types. Yeasts were stored at 5 to 7° C. The letters *A* and *B* designate different *types* of yeast.

The results of this series of observations are shown in some detail in Table I.

The values shown in Table I are considered to be satisfactorily constant throughout, the only serious deviations being with yeasts 3 weeks old or older. This is consistent with findings reported by Larmour and Brockington (1932). It may be observed that even after 21 days some of the yeasts gave values agreeing closely with those obtained with fresh yeast. Yeast B, whether one or 25 days old, gave values agreeing closely with yeast A, which is considered a "slower" yeast than B. Only one lot of B was studied, however, and the data are too few to permit definite conclusions as to whether or not different *types* of yeast can be used interchangeably in this method.

The data in Table I strongly suggest that the use of the specified dough method using 10 gms. of flour and 3% of yeast may be expected to reduce the factor of yeast variability to the extent that it is insignificant where the yeast is reasonably fresh and is kept under conditions of proper refrigeration. The use of this procedure for gassing power determinations should therefore eliminate the necessity for running a standard flour with each set of determinations for the purpose of establishing a yeast "correction factor."

Striking evidence of the superiority of this method over the "suspension-excess yeast" method in the matter of minimizing yeast variability is shown by the data given in Table II.

The data in Table II represent the most extreme instances of variability that were encountered using the "suspension-excess yeast" method. Blish, Sandstedt, and Astleford (1932). Even in these extreme cases, however, the dough method showed reasonably consistent values for the different yeasts.

TABLE I
VARIABILITY OF GASSING POWER VALUES USING DIFFERENT LOTS OF YEAST, AND
YEASTS OF DIFFERENT AGE, BUT WITH FLOUR CONSTANT
Dough Method Using 3% of Yeast

Date	Yeast no.	Age of yeast	Gas pressures ¹					
			1 hour	2 hours	3 hours	4 hours	5 hours	6 hours
			Millimeters of mercury					
Jan. 4 '34	A 0	3 wks.		239	363	412	446	
" 9 "	" 1	4 days	98	231	356	405	439	467
" 10 "	" 1	5 "		238	364	415	448	480
" 25 "	" 4	1 day	93	231	357	410	446	477
Feb. 1 "	" 4	7 days	91	229	354	406	444	468
" 5 "	" 4	11 "	88		353	402	434	467
" 7 "	" 1	33 "	88	224		396	432	455
" 8 "	" 5	1 day	92	234	356	408	440	473
" 13 "	" 4	19 days	87	228		397	433	462
" 14 "	" 5	7 "	89	232		408	443	475
" 21 "	" 6	5 "	94	230		402	435	461
" 22 "	" 4	28 "	76	179		383	420	445
" 27 "	" 7	1 day		232	355	405	439	465
" 28 "	" 5	21 days	81		336	392	427	453
Mar. 7 "	" 7	8 "	88		349	400	431	456
" 8 "	" 8	1 day	92	227		406	440	465
" 13 "	" 9	1 "	88		351	404	437	463
" 16 "	" 6	28 days	84			403		461
" 16 "	" 7	17 "	91			416		475
" 16 "	B 1	1 day	89			404		467
" 20 "	A 10	4 days	93			413		475
" 22 "	" 11	1 day	90			400		460
" 27 "	" 12	1 "	86			403		472
Apr. 9 "	" 13	9 days				405		460
" 9 "	" 14	5 "				396		452
" 9 "	" 15	1 day				399		456
" 10 "	" 8	34 days	79			377		434
" 10 "	B 1	25 "	95			403		458
" 17 "	A 16	4 "	91			402		458
" 19 "	" 17	1 day	89			400		456
" 24 "	" 18	1 "	88			400		456
" 30 "	" 19	3 days	90			410		468
May 3 "	" 20	1 day	86			403		462
Average ²			90.2	231.2	355.0	404.6	439.1	465.4
Standard deviation ²			2.98	2.99	4.00	5.04	5.09	7.45
Probable error of a determination ²			2.00	2.01	2.69	3.39	3.42	5.01
Probable error of the mean ²			.46	.64	.90	.67	.95	.98

¹ Each value is the average of closely agreeing duplicates.

² Only yeasts under 21 days old included.

TABLE II
YEAST VARIABILITY BY "SUSPENSION-EXCESS YEAST" METHOD AS CONTRASTED WITH
DOUGH METHOD USING 3% OF YEAST

Date	Yeast no.	Age of yeast	Gas Pressures (Averages of duplicates)			
			Dough method with 3% yeast			Suspension method— Enormous yeast excess ¹
			1 hour	4 hours	6 hours	1 hour
		Days	Millimeters of mercury			
Mar. 16 '34	A 7	17	91	416	475	125
" 16 "	B 1	1	89	404	467	189
" 22 "	A 11	1	90	400	460	147

¹ Method described by Blish, Sandstedt, and Astleford (1932).

Why is yeast variability a factor of importance in the one type of method but not in the other? A number of experiments were undertaken in an effort to account for this situation. No attempt will be made to present any thorough review of the voluminous literature relative to peculiarities of behavior and properties of yeasts of various types and under the infinite number of environmental conditions that may be established or encountered.

Among the important factors that influence yeast behaviour, aside from the more obvious ones, such as temperature, pH, yeast concentration, nutritive media, etc., are the content and stability, respectively, of the yeast enzymes, invertase, maltase, and zymase. There is also the possibility of glycogen metabolism by the yeast, and, in the case of ordinary bakers' compressed yeast, the presence of other substances used as fillers, "regulators," etc., may be of importance.

Throughout these studies it has been assumed that sucrose and maltose must be hydrolyzed to the simple monosaccharides—by the yeast enzymes invertase and maltase, respectively—before they can be acted upon by the yeast zymase.

The Instability of Yeast Maltase

It has been repeatedly shown that yeast maltase is far more unstable than yeast invertase, and that unless stored at low temperatures the yeast maltase rapidly loses its activity. Harding and Nicholson (1933) find that bakers' yeast loses its maltase activity almost entirely after standing for several days at room temperature.

Figure 3 shows graphically some typical instances of the manner in which the rates of fermentation of pure sucrose, glucose, and maltose, respectively, were affected by age and type of the yeast. In each determination the sugar was dissolved in 7 cc. of water (containing 0.3 gm. of suspended yeast) and added to 10 gms. of commercial wheat starch to make a dough comparable to doughs made in the gassing power determinations with flour.

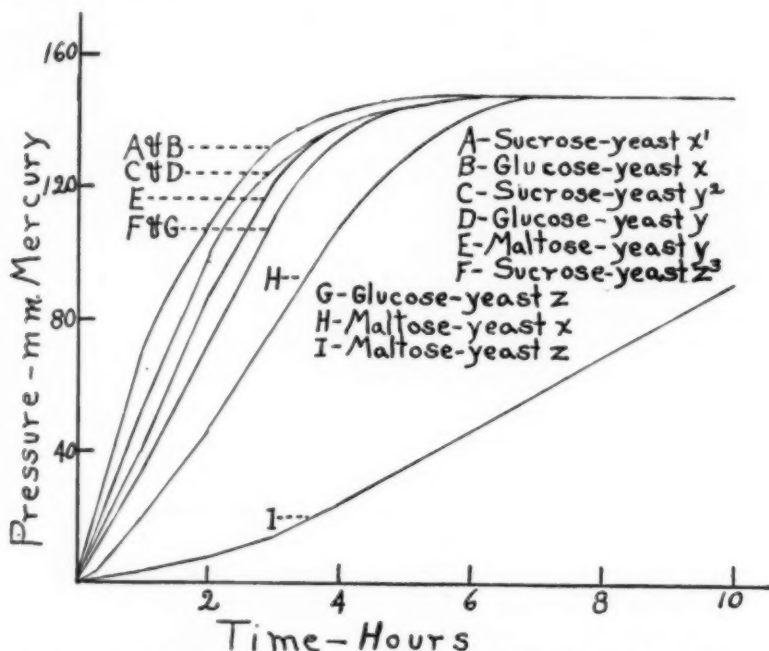


Fig. 3. Rates of fermentation of sugars with fresh and old yeasts (200 mgs. of sugars used).
 1. X, Fresh yeast, Type A. 2. Y, Fresh yeast, Type B. 3. Z, Type A yeast, after storing 7 days at room temperature.

The tendencies shown in Figure 3 were verified by many trials and experiments. Curves A and B coincide. C coincides with D, and F is identical with G. This shows that each individual yeast fermented sucrose at the same rate as it did glucose. Yeast A fermented sucrose and glucose at a slightly faster rate than did yeast B. Yeast B fermented maltose at a faster rate than yeast A.

The results with the yeast A, after keeping for 7 days at room temperature, show that the maltose fermenting power has deteriorated far more than the glucose and sucrose fermenting powers, and more than the zymase activity.

The instability of yeast maltose offers one possible and an obvious explanation of loss of yeast activity due to age, or inadequate refrigera-

tion or both. It does not, however, explain the situation typified by the data in Table II, where a 17 day old yeast gave a very low flour gassing power value when used in large excess in water suspension, but a "normal" value when used in the amount of 3% with the "dough type" of gassing power test.

The Use of Excessive Amounts of Yeast in Gassing Power Tests by the Dough Method, with Pure Sucrose

In an effort to secure further information relative to the issues under consideration, further gassing power tests were conducted with pure sucrose, using "normal" (0.3 gm.) and "excessive" (10 gms.) quantities of various yeasts. The procedure followed in each test was to make a "dough" using 10 gms. of starch, and 7 cc. of water containing 100 mgs. of sucrose and the required quantity of yeast in suspension. Fermentation was allowed to proceed (in the manometric apparatus shown in Figures 1 and 2) until the pressure reached a maximum and constant value, indicating that fermentation had proceeded as far as it would go. Rates of fermentation are not considered in these tests, but were variable.

A series of typical data resulting from studies of this character is shown in Table III.

TABLE III
MAXIMUM PRESSURES FROM FERMENTATION OF SUCROSE BY "NORMAL" AND "EXCESSIVE" AMOUNTS OF VARIOUS YEASTS

Yeast	Age	Pressures	
		With 0.3 gm. of yeast	With 10.0 gm. of yeast
		<i>Millimeters of mercury</i>	
B 1	5 days	71	98
A 11	1 day	69	67
A 7	22 days	71	43
A 6X	32 " 1	71	39

¹ 25 days in the refrigerator and 7 days at room temperature.

Table III shows that even under extreme conditions of yeast "freshness" the values were concordant when only 0.3 gm. of yeast was used. When 10 gms. of yeast were used under strictly comparable conditions, the values ranged from 98 to 39. The data given in Table III raise three questions. (1) Why did the *excessive* amount of yeast give maximum pressures that were much lower than those obtained with *small* amount of yeast? (2) Why, considering only the Type A yeast

used in excessive amount, did the values decrease according to the "age" of the yeast? (3) Why did yeast *B* give a much higher pressure than yeast *A*, where both were comparatively fresh and were used in *excessive* amount, whereas the same yeasts gave concordant values when used in small amount?

The present opinion of the writers is that the lower values obtained with the excessive quantities of yeast are due to glycogen storage,⁴ and that the tendency of the yeast to convert sugar into glycogen—instead of fermenting it—probably increases with age. If that is the true situation, it is obvious that the magnitude of this factor would diminish with the quantity of yeast present, and this would explain in large part the closer concordance of values when the small amounts of yeasts are used.

The discordant values given by *fresh* yeasts *A* and *B* when used in *excessive* amount, as contrasted with the good agreement between values for the same yeasts when used in the *small* amounts, was a matter for which no definite and satisfactory explanation was found. If the results had been obtained from *water suspensions*, instead of from doughs or pastes made with a starch filler a ready explanation would have been afforded by the "blank" values given by the two yeast types, *A* and *B*. Thus, for example, 10 gms. of yeast *B*, alone, in 35 cc. of water, gave a pressure of 41 mm. of mercury in 2 hours, while yeast *A* under identical conditions gave blank values usually ranging from 11 to 19 mm. In the dough type of test, however, with 10 gms. of yeast *B*, 10 gms. of starch, and 7 cc. of water, no appreciable "blank" value was found.

The fact that considerable gas is produced by the yeast alone, when suspended in water in the suspension type of method, but not in the dough type, is apparent, although the reason for it is not known to the writers. At any rate, the data indicate that even two different *types* of yeast can give concordant gassing power values when used in small amounts in the *dough* test, whereas the results are discordant when the same yeasts are used in *excessive* quantity, either in the dough or suspension type of method.

Other experiments, using the two types of yeast in excessive amounts, gave anomalous results and need not be here reported. Concordant and consistent gassing power values were obtained only when the yeasts were used in the smaller amounts.

Effect of "Age" upon Hydrogen-Ion Concentration of Yeast

It is apparent that if yeast hydrogen-ion concentration is a variable factor, the pH effect should be far more drastic in the presence of

⁴ Suggested to the writers by Dr. C. N. Frey, of the Fleischmann Laboratories.

yeast excess than where only a small quantity of yeast is used. A few observations showed that the pH of bakers' compressed yeast increases with age. A sample of yeast *A*, when fresh, showed a pH of 4.6. After 5 days storage at 6° to 8° the pH had increased to 6.6. Four days later the pH was still 6.6. The same yeast after a week at room temperature showed a pH of 7.4. It is, of course, possible to control this type of variable by using a buffer, as has been done by Schultz and Kirby (1933), and Landis (1934). Using the dough test with the *small* quantity of yeast, the writers have found no evidence that yeast pH variability is a factor of any significant influence, or that there is any need for buffer control of pH.

An Unidentified Yeast "Stimulant" in Flour

All influences considered, it is not at all surprising that yeast "age" and yeast type are factors capable of causing pronounced variability in gassing power tests where the yeast is used in large excess. Nevertheless, the foregoing considerations do not satisfactorily explain why it is that these same factors apparently cause no serious variability when the ratio of yeast to flour is *small* (3% yeast).

If yeast maltase is unstable, and deteriorates rapidly with the age of the yeast, how can yeast that is 20 days old ferment the maltose produced by flour diastase as rapidly as fresh yeast? Experiments with flour, and with pure sugars show clearly that the flour itself possesses the property of restoring maltase activity in an old yeast. Whereas old yeast fermented maltose alone very slowly, the addition of flour to the maltose causes the fermentation of the latter to proceed rapidly, with the same yeast. It was at first thought probable that ordinary flour has some maltase activity, but none could be demonstrated by any methods attempted. It was later found that flour retains this stimulating property even after drastic treatment with acid and alcohol to render it entirely inert enzymatically. This indicates that flour contains some factor that either re-activates the yeast maltase or permits the yeast to ferment maltose directly.

A typical and striking instance of this is shown in Figure 4. The yeast used in securing these data had been kept at room temperature during very warm weather for 7 days, followed by 7 days storage in the refrigerator. The flour was inactivated by exposure to dilute HCl for one hour, followed by several washings with strong alcohol, neutralization to bromthymol blue, and drying at room temperature. This flour, alone, gave no gas pressure whatsoever over a period of several hours when doughed with the yeast. Doughs were made using 7 cc. of water, 10 gms. of flour or starch (as shown on the chart) and 0.3

gm. of the old yeast. These doughs were put into the pressure apparatus and maintained at 30° C.

Considering that the flour itself had no gassing power whatsoever (as was shown by blank determinations), and that fermentation of the maltose, alone was negligible for many hours, it is evident from curve no. 3 that the inactivated flour possessed a striking ability to restore the maltose fermenting power of the yeast. Peptone had a very slight stimulating effect.

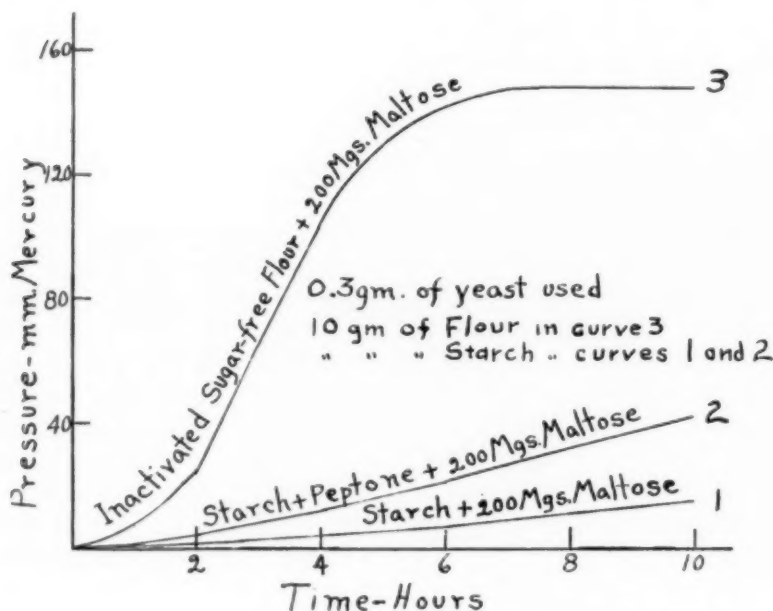


Fig. 4. Stimulating effect of enzymatically inactive, sugar-free flour on old yeast that had lost its capacity to ferment pure maltose in the absence of stimulant.

This evidence that flour possesses a maltase "stimulant" was confirmed and verified by additional tests involving both active and inactive flours. The nature of the stimulating agent is not at present known to the writers.

It seems probable that this situation substantially explains why it is that yeast variability—due to differences in age or type of yeast—is not a factor of significant importance in flour gassing power tests conducted according to the manometric procedure herein specified, and involving small doughs in which the ratio of flour to yeast is high (100 to 3).

Any yeast of the *A* or *B* type may be expected to give satisfactory results,—provided it has been kept under proper refrigeration—up to an "age" of 2 and possibly 3 weeks. With reasonably fresh yeast

available, it should not be necessary to run a standard flour with each series in order to establish a yeast "correction factor."

This is in contrast to the situation that is encountered when using manometric procedures which involve the use of yeast in excessive quantities. Here it is found that unless the yeast is quite constant as to age and type variable gassing power values are obtained, and a yeast "correction factor" must be frequently established and applied.

The Pressuremeter

Subsequent to the findings presented in the foregoing report, the gassing power equipment shown in Figures 1 and 2 has been substantially improved as to durability and convenience. The three parts,⁵ exclusive of the manometer and the valve, are made of aluminum, and are shown in Figures 5 and 6.

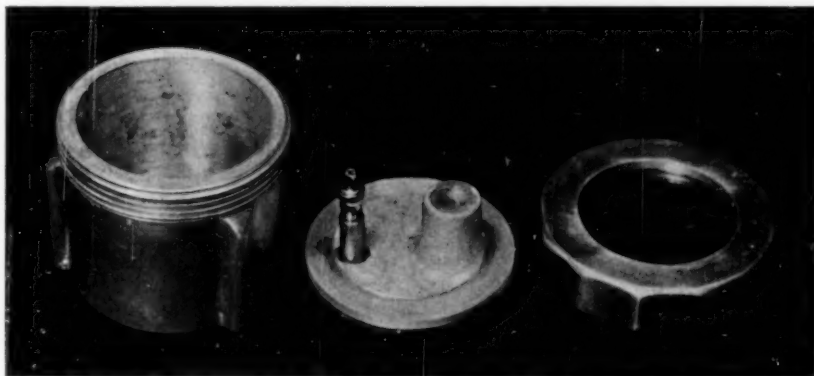


Fig. 5. Individual parts of the pressuremeter, exclusive of the manometer.

The aluminum parts are practically indestructible. The rubber fruit jar gasket, which fits into a groove under the lid, is removeable and replaceable. The lid is to be fitted with a mercury manometer after the manner already described, and as shown in Figures 1 and 2. A convenient total height for the manometer is 28 inches, with the top bend at 14 inches from the top of the lid. Barometer tubing should be used for making the manometers. The pressuremeters will sink in water from their own weight, and require no extra weights to hold them down in the water bath.

No strap wrenches are needed for the purpose of screwing the lid down tightly. The three vertical ribs on the side of the aluminum cup make it possible to use a simple wooden frame with three grooves cor-

⁵ "Pressuremeters," without the manometers, are made by the National Manufacturing Company, Lincoln, Nebraska.

responding to the three ribs on the cup. This frame may be permanently fastened to the table. The collar is 12-sided, permitting the use of a wooden wrench for tightening or unscrewing.

The aluminum cups have a 250 cc. capacity, and accordingly the aluminum pressuremeters give values essentially in agreement with values obtained by the "fruit-jar" equipment shown in Figures 1 and 2.

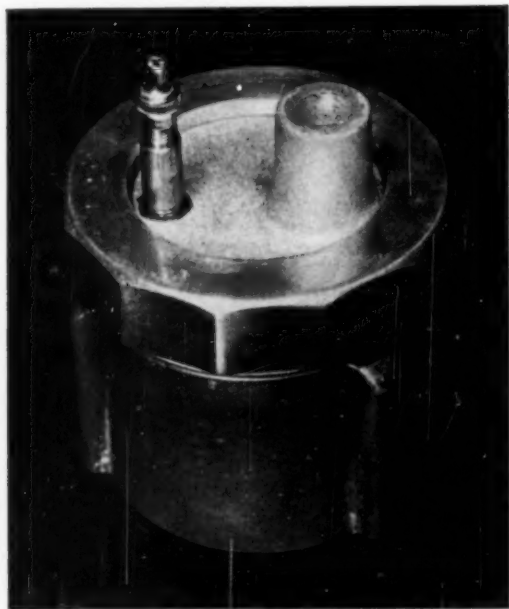


Fig. 6. Pressuremeter assembled, but without manometer.

Summary

Yeast variability due to differences in age or type of yeast is an important factor in manometric gassing power tests where the ratio of flour to yeast is small. Unless yeast of assured constant properties is always available, this method requires that a standard flour be always included in a series of gassing power tests for the purpose of establishing a yeast "correction factor." This situation may possibly be explained by the fact that yeasts of different ages and types vary in glycogen storage capacity, and in pH. These factors become more serious as the ratio of flour to yeast decreases.

These factors of yeast variability become more insignificant as to their effect on flour gassing power tests as the ratio of flour to yeast increases. Using a small dough test in suitable pressure apparatus, and with only 3% of yeast, consistent and concordant results have been ob-

tained using the same flour with yeasts of different ages and types over a period of several months. Yeasts varying from 1 to 21 days in age gave closely agreeing results, provided the yeasts were kept stored at 6° to 8° C. By using a dough instead of a suspension, the variable factor of shaking is eliminated.

The maltase activity of bakers' compressed yeast rapidly deteriorates on storage. That this is not a serious factor causing variability in flour gassing power determinations, using the small quantities of yeast—as might be expected since maltose is the sugar produced by flour diastatic activity—is due to the presence in flour of an active maltase “stimulant” whose nature is unknown to the writers. This “stimulant” exists even in flour that has been rendered enzymatically inert and sugar-free by treatment with acid followed by extraction with strong alcohol.

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COMPARISON OF A BROMATE AND MALT-PHOSPHATE-BROMATE FORMULA IN TESTING WHEAT QUALITY FOR THE PLANT BREEDER^{1, 2}

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Introduction

In recent years, the periodic occurrence of severe rust epidemics and the expansion of the wheat growing areas to the North have led to an extensive wheat breeding program in Canada, with the object of producing new varieties of hard red spring wheat for the Canadian prairies which would combine earliness, rust resistance, and other desirable agronomic characteristics together with high milling and baking quality. In the prosecution of this program, the most promising hybrids produced by the individual plant breeders located at the various experimental stations are grown side by side at a number of points in each of the prairie provinces. Several standard varieties of known quality are included to serve as reference standards for evaluating the new wheats, on both an agronomic and quality basis.

By this means all the varieties are grown under several sets of comparable environmental conditions and the differential agronomic behaviour of the wheats to the varying environmental factors may thus be determined. Under these conditions, differences in quality between the wheats grown at the same point may be ascribed to genetic factors. In the evaluation of these wheats, the Associate Committee on Grain Research of the National Research Council of Canada has been co-operating with the plant breeders of the Experimental Farms Branch of the Dominion Department of Agriculture and of the Universities of Alberta, Saskatchewan, and Manitoba by arranging for tests on individual samples grown at each station and also on composite samples obtained by mixing the different lots of any particular variety grown in each of the prairie provinces.

The task of evaluating the quality of these varieties is divided between four cereal laboratories situated in Ontario, Manitoba, Saskatchewan, and Alberta. In addition to such tests as protein and carotene

¹ Subcommittee report, 1933-34 Committee on the Standardization of Laboratory Baking.

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content, viscosity, diastatic activity and gas production, the flours are baked by a number of test baking procedures in order to secure as complete information as possible on their baking characteristics.

When the collaborative testing of Western Canadian wheat was first instituted by the Associate Committee on Grain Research several years ago, it soon became evident that test baking methods which proved satisfactory for the evaluation of commercial flours were unsuited to flours experimentally milled from strong Canadian wheats. This point has recently been dealt with by Geddes and Larmour (1933) who point out that the determination of wheat quality is quite a different and more difficult problem than the evaluation of the quality of a commercial flour. In the former case the tests are conducted on experimentally milled flours which are for the most part baked after only a limited amount of aging and without any bleaching treatment, the problem being to determine the inherent strength or maximum capabilities of such experimental material and hence secure an estimate of its value in commerce. In order to accomplish this, it is necessary to employ baking methods which ensure, not only that gas production will be at a sufficiently high level to preclude yeast starvation, but also that the gluten will be developed to a point where it will exhibit its maximum potentialities. The gluten of freshly milled unbleached flours of high protein content, as pointed out by Geddes and Larmour (1933), is very resistant to development by fermentation and this characteristic may be largely overcome by the use of 0.001% potassium bromate in the baking formula.

The loaf volumes obtained by the bromate formula on unaged and untreated flours closely parallel those from the same flours fully matured by natural or artificial means when baked by the basic formula. The bromate formula accordingly gives a truer indication of the commercial value of such "gluten-bound" flours and in testing the quality of wheats it would appear that it should be regarded as the basic formula and not as a supplementary test for such work.

With regard to the question of adequate gas production, Geddes and Larmour (1933) have shown that while potassium bromate modifies the physical properties of the gluten, as reflected in the extensibility of the dough, it does not influence the rate nor the amount of carbon dioxide produced. It is quite generally recognized that flours commercially milled from sound Western Canadian wheats are, in general, characterized by low diastatic activity, and in commercial baking practice diastatic supplements are almost universally employed, unless the flours are blended with weaker flours of high diastatic value. It is also well known that experimentally milled flours are lower in diastatic activity than commercial flours; thus Pascoe, Gortner, and Sherwood (1930) found the saccharogenic activity of commercial flours to be from 1 to

4 times that of flours milled from the same wheat on a small experimental mill, apparently due to differences in granulation.

In a study of the relative baking qualities of a series of comparable experimentally and commercially milled flours, Markley and Bailey (1933) found that when the A. A. C. C. basic baking method was applied the correlation between the loaf volumes of the commercial and experimental flours was not significant. When baked by the high diastatic procedure recommended by Markley and Bailey (1931), the relative placings of the commercial flours were only slightly altered by the change in baking method, but the experimental flours were given quite a different rating as a consequence of the increase in gassing power. Statistical constants computed for the loaf volume data showed that the commercial and experimental flour loaf volumes were not significantly different for the high diastatic method and that only the experimental flours needed diastatic supplementation.

In determining the relative strength of Western Canadian wheats of naturally low diastatic activity, involving as it does, tests on experimentally milled flours, there is a grave danger that yeast starvation will occur when using the A. A. C. C. basic or bromate test. Whether or not adequate gas production is maintained will depend upon the diastatic activity of the experimental flours under study. The application of several baking formulas to the 1932 plant breeders' samples were reported by Larmour, Geddes, and Whiteside (1933). Of the several formulas tried, that containing diastatic malt and mono-ammonium phosphate in addition to potassium bromate gave the greatest differentiation in loaf volume, the results bearing little relation to the diastatic activity of the flours. The bromate formula, while placing the standard reference varieties in what is regarded as their proper relative positions, gave somewhat different ratings than the malt-phosphate-bromate formula in the instance of many of the new varieties, and no decision was reached as to which formula was the better for the purpose at hand.

In the testing of the 1933 crop samples, involving 36 varieties, data were secured which definitely indicate the superiority of a formula employing both diastatic supplements and an oxidizing agent for work of this nature. Some of the results obtained on the Alberta and Manitoba composites seem to be of sufficient general interest to warrant a brief report.

Experimental

The straight grade flours experimentally milled from the Alberta and Manitoba composite samples of wheat representing the 36 varieties under study were baked in one of the collaborating laboratories by two methods designated as the bromate and malt-phosphate-bromate for-

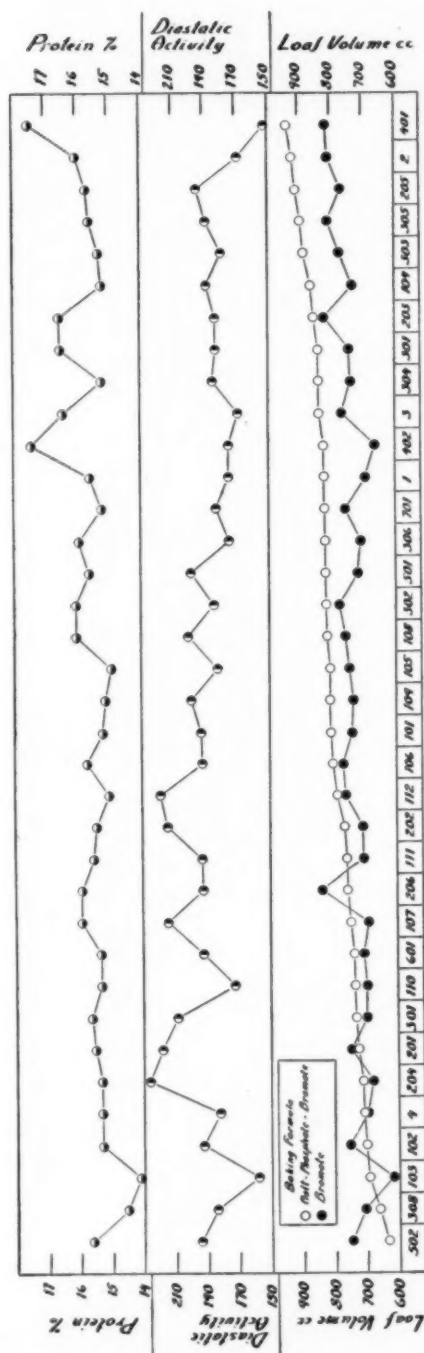


Fig. 1. Graphical presentation of data for wheat protein, diastatic activity, and loaf volumes by the bromate and malt-phosphate-bromate formulas on 36 hard red spring wheat varieties grown in Alberta.

mulas. In the former, 0.001% KBrO_3 was used, and in the latter, 0.5% diastatic malt (approx. 200° Lintner), 0.1% $\text{NH}_4\text{H}_2\text{PO}_4$, and 0.001% KBrO_3 , in addition to the ingredients specified in the A. A. C. C. basic baking test. The conditions laid down in the A. A. C. C. procedure were followed with the exception that the absorption was varied to suit the flour, the doughs were machine mixed and baked in "low form" tins. Diastatic activity was determined on each sample, using the method recently outlined by Blish and Sandstedt (1933). These data, together with the protein content of the wheats expressed on a 13.5% moisture basis, are represented graphically in Figures 1 and 2 for the Alberta and Manitoba composites respectively, and the statistical constants which have been computed are summarized in Table I. To facili-

TABLE I

STATISTICAL CONSTANTS FOR WHEAT PROTEIN, DIASTATIC ACTIVITY AND LOAF VOLUME BY THE BROMATE AND MALT-PHOSPHATE-BROMATE FORMULAS

	Means		Standard deviations		Range			
	Alta. comp.	Man. comp.	Alta. comp.	Man. comp.	Alta. min.	Comp. max.	Man. min.	Comp. max.
Wheat protein (p)	15.7	15.0	.716	.698	14.1	17.5	13.8	17.2
Diastatic activity (d)	188.6	92.2	16.38	10.46	152	226	72	120
Loaf volume (v_1) bromate formula	734.6	595.5	44.81	74.04	616	834	426	715
Loaf volume (v_2) malt-phosphate bromate formula	792.9	773.4	72.13	110.02	632	938	557	1002
Response (r)	58.3	177.9	67.94	109.89	-115	143	-16	537

Total correlations			First order correlations		
Correlation	Alta. comp.	Man. comp.	Correlation	Alta. comp.	Man. comp.
r_{pd}	-.272	-.292			
r_{pv_1}	.286	-.025	$d^r pv_1$.307	.245
r_{pv_2}	.594	.760	$d^r pv_2$.554	.783
r_{dv_1}	.035	.677	$p^r dv_1$.122	.700
r_{dv_2}	-.381	-.038	$p^r dv_2$	-.284	.296
r_{pr}	.441	.781	$d^r pr$.374	.766
r_{dr}	-.428	-.495	$p^r dr$	-.357	-.447
Value of r at 5% pt. .324			.329		

Wheat protein is expressed in per cent (13.5% moisture basis), diastatic activity in Rumsey Units, loaf volume and response in cc. Response in loaf volume was computed by subtracting the bromate volume from that given by the malt-phosphate-bromate formula.

tate comparison, the samples have been arranged in the same order in both graphs; namely, in order of increasing loaf volume by the malt-phosphate-bromate formula for the Alberta composites.

It will be noted from Figures 1 and 2 that there is considerable variation in the relative placings of the samples by the two formulas, particularly in the instance of the Manitoba composites, where the bromate loaf volume is greatly influenced by variations in diastatic activity. The standard reference varieties, designated as numbers 1, 2, 3, and 4, are Marquis, Reward, Ceres, and Huron respectively, the relative strength of which, in general, is known to be in the order—Reward, first, Marquis and Ceres, second, and Huron, third. The relative placings of these standard varieties in the series of 36 samples as indicated by loaf volume, for the two formulas, are given in Table II.

TABLE II
RELATIVE PLACING OF THE STANDARD VARIETIES IN THE SERIES

	Series no. of placing in regard to loaf volume			
	Alberta composites		Manitoba composites	
	Bromate fromula	Malt- phosphate- bromate formula	Bromate formula	Malt- phosphate- bromate formula
Reward	4	2	31	3
Marquis	32	13	22	21
Ceres	9	10	2	8
Huron	29	32	12	14

In the Alberta series, the varieties are placed by the malt-phosphate-bromate formula in what is generally regarded as their relative strength, while by the bromate formula, the placing of Marquis is out of line. In the Manitoba series, the most notable discrepancy is in the relative placings of Reward wheat by the two formulas.

The flours in both sets were all milled from sound wheats and the low placing of Marquis and Reward by the bromate formula in the Alberta and Manitoba series, coupled with widely different placings of the new varieties by the two formulas led to a statistical examination of the data.

From the values recorded in Table I it will be noted that the diastatic activity for the Manitoba series is very low and the addition of malt extract produces a mean loaf volume response of 177.9 cc. In the Alberta series the mean diastatic activity is approximately double that of the Manitoba series and in this instance the response to malt and phos-

phate is only 58.3 cc. The relations existing between wheat protein, diastatic activity, and loaf volume by the two formulas, as shown by the total and first order correlations, require little comment.

The correlations between protein and bromate loaf volume of .286 and $-.025$ respectively for the Alberta and Manitoba series are not significant, the corresponding values for the malt-phosphate-bromate formula, however, of .594 and .760 are highly significant. The significance of the increase in the correlations between protein and loaf volume as a result of the addition of diastatic malt and phosphate has been tested and for the Alberta samples the values .286 and .594 are not significantly different. On the other hand, for the Manitoba composites the increase in the correlation from $-.025$ to .760 is highly significant.

The correlations involving diastatic activity and loaf volume are of greater interest. In the Alberta series, bromate loaf volume is uninfluenced by variations in the diastatic activity of the flour, as shown by the low and insignificant correlation of .035. In the Manitoba series, however, where the general level of diastatic activity is low, an increase in diastatic activity is accompanied by an increase in bromate loaf volume, as indicated by the fairly high and significant correlation of .677. The use of the malt-phosphate-bromate formula entirely eliminates the effect of variations in diastatic activity on loaf volume in the latter instance, but it is worthy of note that with this baking procedure the loaf volume of the Alberta samples is negatively correlated with the diastatic activity of the flour. It will also be observed that the response to loaf volume in both series, obtained by the addition of malt and phosphate to the baking formula, increases with increasing protein content and, as would be expected, decreases with increasing diastatic activity of the flours.

The same general relations between these variables are shown by the first order correlations. With diastatic activity held constant, the correlations between protein and loaf volume are significant for the malt-phosphate-bromate and insignificant for the bromate formulas. When protein is held constant, bromate loaf volume in the Alberta series is not related to the diastatic activity of the flour, but these variables are highly correlated in the Manitoba series. Using the malt-phosphate-bromate formula, the partial correlations p^{rdv_2} of $-.284$ and .296 for the Alberta and Manitoba series respectively are below the level of significance.

Discussion

The statistical constants show quite conclusively that with the Manitoba composites, the use of diastatic supplements is necessary in order to prevent yeast starvation and eliminate the effect of variations in diastatic

activity of the flours. In the Alberta series, in which the diastatic activity of the flours was of a much higher order, however, the bromate loaf volumes were uninfluenced by this variable, and the question naturally arises as to which formula should be used as a basis for rating the relative strength of the samples. The correlation between the loaf volumes by the two baking methods was computed and found to be .438, which is not of a high order of magnitude and indicates a widely different relative placing of the Alberta samples by the two formulas. Since the correlation between diastatic activity and bromate loaf volume on the Alberta series was low (.035) and that between this variable and loaf volume by the malt-phosphate-bromate formula for the Manitoba samples correspondingly low ($-.038$), it was thought that these two sets of loaf volumes might be highly correlated. The correlation, however, was found to be only 0.388 and hence does not indicate that diastatic supplements should be omitted with high diastatic flours in order to secure similar placings of flours milled from wheats of the same varieties but of low diastatic activity, to which it is necessary to add diastatic supplements to preclude yeast starvation. On the other hand, the correlation between the two sets of loaf volumes by the malt-phosphate-bromate formula is 0.485, which is not significantly higher than the correlation .388 referred to above, and hence no indication is obtained as to which formula is superior.

In order to secure a satisfactory differentiation in strength, it is desirable that the range in values should be wide. From this standpoint the malt-phosphate-bromate formula is superior, the spreads in loaf volume being 306 cc. and 445 cc. for the Alberta and Manitoba series respectively, as compared with 218 cc. and 289 cc. for the bromate formula. The uniform tendency towards higher correlations between protein and loaf volume by the malt-phosphate-bromate formula should also be borne in mind. These considerations, together with what is believed to be a more satisfactory placing of the standard varieties, lead us to regard this formula as the better one for rating the varieties in both sets of samples.

It is of interest to consider the effect of diastatic preparations on gluten development. It has been found by numerous investigators that such preparations, presumably due to the proteolytic enzymes present, exert an effect on the physical properties of the gluten and for this reason the use of such supplements is objected to by Landis and Frey (1933). Recently Larmour and Brockington (1933), in a study of baking formulas containing varying amounts of sugar, potassium bromate, and diastatic malt extract, have shown that the higher concentrations of malt employed made the dough more sensitive to the action of

an overdosage of bromate. This indicates that the influence of malt extract and potassium bromate on gluten development is in the same direction and where the colloidal character of the gluten is modified by the action of malt, less bromate is required to bring it to its optimum condition for baking.

Some support for this explanation is provided by the results obtained in the present study. With the Alberta series when diastatic malt extract is superimposed upon the bromate formula, the total correlation between diastatic activity and loaf volume is changed from .035 to —.381, the corresponding first order correlations in which protein is held constant being .122 and —.284. While neither of the partial correlations is significant there is an indication that the loaf volume tends to be depressed when the diastatic activity is increased beyond a certain limit.

As already pointed out, the problem in evaluating red spring wheat varieties is to secure a measure of the inherent strength or maximum capabilities of the material, and as the tests are of necessity made on experimentally milled flours, the desired result can only be attained by bringing the gluten to its optimum condition for baking, and ensuring that gas production is not a limiting factor. Gluten development, as reflected by loaf volume, may be brought about by mechanical mixing, by fermentation, by the use of oxidizing agents (such as potassium bromate), and by diastatic preparations.

When diastatic preparations are used to increase gas production, one cannot be certain that the maximum capabilities of a flour are manifested by the baking results in view of their dual effect. When such preparations are added to a series of flours where gas production is not a limiting factor and the gluten is developed to its approximate optimum by other means, such as by the use of potassium bromate, there is definite indication that the loaf volume of the flours of high diastatic activity is depressed as a result of overdevelopment of the gluten. Consequently, in the instance of flours deficient in gassing power, the increased loaf volume resulting from the use of such preparations may not be a true indication of the relative strength of such a series of flours. While the loaf volume is increased by virtue of the increased gas production, the action on the gluten may further increase or decrease the volume depending upon the extent of gluten development in relation to the optimum, hence the net increase in volume is a function of the two effects of diastatic malt.

These considerations lend support to the view of Landis and Frey (1933) that the gassing power of flours should be corrected by non-diastatic supplements.

Summary

In evaluating the relative quality of strong wheats involving tests on experimentally milled flours, it is necessary to employ baking methods which not only provide adequate gas production but also to ensure that the gluten will be developed to a point where it will exhibit its maximum potentialities.

The "gluten bound" condition of freshly milled, untreated, experimentally milled flours may be largely overcome by the use of potassium bromate in the baking formula, the results closely paralleling those obtained by the basic test on flours matured by natural or artificial means. The bromate test should therefore be regarded as the basic procedure and not as a supplementary test for such work.

Flours experimentally milled from sound strong wheats tend to be low in diastatic activity, and it is necessary to ensure that the baking method employed precludes yeast starvation.

Baking tests on two sets of samples of 36 red spring wheat varieties, prepared by mixing individual lots of wheat of each variety grown in Alberta and Manitoba respectively, were conducted by the bromate (0.001% KBrO_3) formula and also by a formula containing in addition 0.5% diastatic malt extract (200° Lintner) and 0.1% $\text{NH}_4\text{H}_2\text{PO}_4$, and the relation between loaf volume, wheat protein, and diastatic activity studied.

In the Alberta series, with a mean diastatic activity of 188.6, bromate loaf volume was independent of diastatic activity, while, in the Manitoba series, with a mean diastatic activity of 92.2, bromate loaf volume was positively correlated with diastatic activity.

In the latter series, the addition of malt and phosphate to the baking formula entirely removed the influence of flour diastatic activity on loaf volume, while the application of this formula to the Alberta samples resulted in a negative correlation between loaf volume and diastatic activity.

The response in loaf volume obtained by the addition of diastatic malt and ammonium acid phosphate is positively correlated with protein content and negatively correlated with diastatic activity of the flours.

The effect of diastatic preparations on gluten development is discussed.

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FERMENTATION RESPONSE AND FERMENTATION TOLERANCE

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(Read at the Annual Meeting, June, 1933)

Introduction

The fact that the fermentation process has a modifying effect upon the flour colloids in the dough is well recognized. Thus the practical baker speaks of the "age" of the dough which is judged roughly by the feel when touched or pulled with the hands. It seems to be associated with a softening effect or an increase in the pliability. The term development has often been used to describe this change. Over-aged doughs usually have a tendency to become sticky and if fermentation has proceeded too far it is impossible to mold the dough by machine (Figure 1).

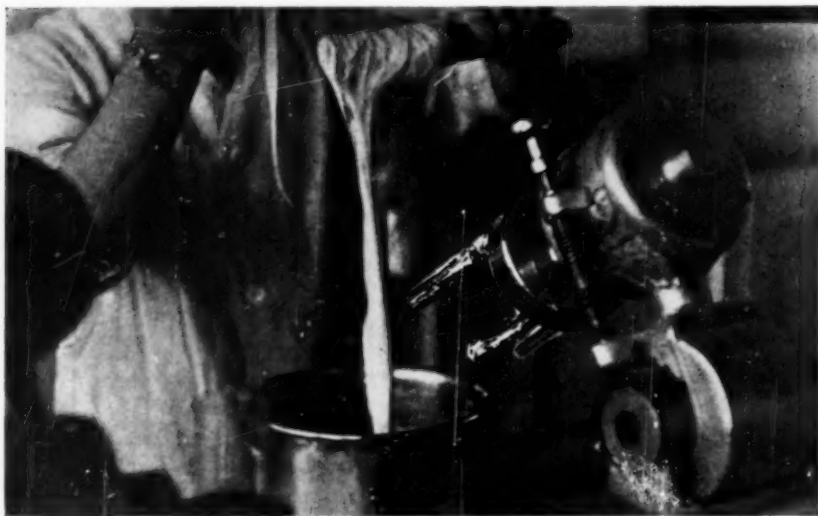


Fig. 1. The extreme of fermentation response. Removing a dough from the jar after excessive fermentation. Such a dough could not be machine moulded.

Physical and Chemical Methods of Measurement

These changes are of such a subtle, ill-defined nature that it is difficult to find a quantitative measure. Various methods may be used to follow

these changes. The phenomenon of peptization has been extensively studied by Gortner *et al.* (1929), Harris (1931), and others. Harrell (1927) has devised a ballistic instrument for measuring the plasticity of the dough. Again investigators (Sharp and Gortner (1924), Johnson (1927)), have made use of imbibition and viscosity methods. For example, the viscosity of a dough disintegrated with a fixed amount of peptizing solution as measured by a wattmeter should give a rough estimate of the changes taking place. As an alternative, the approximate time required to disintegrate a dough after varying periods of fermentation can be determined. Typical results by this method are shown in Figure 2. These measurements are only approximate and subject to

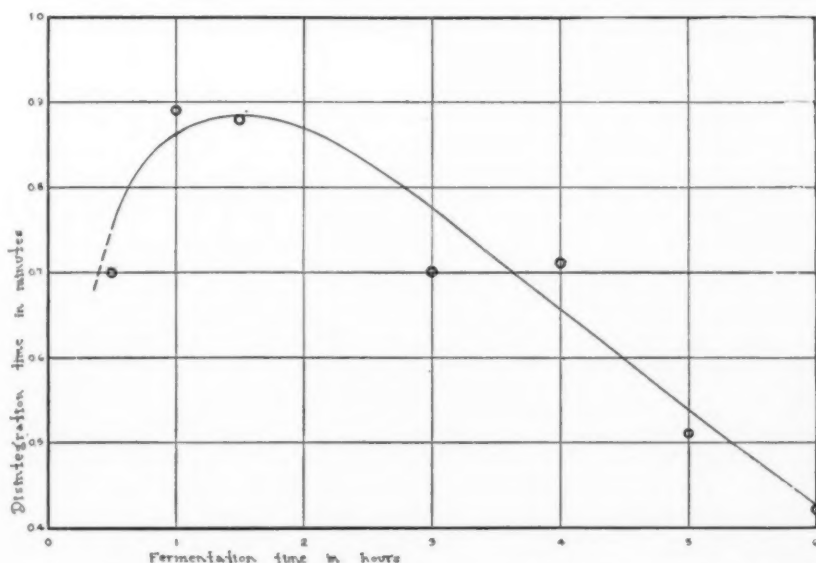


Fig. 2. Effect of fermentation on a colloidal property. The time required to disintegrate a 100-gram (flour) dough with a power driven egg beater using 50 cc. of N/1 sulfuric acid.

large variations, but nevertheless give the general trend of the changes taking place.

Practical Baking Methods

The majority of efforts to measure the changes have been made by actual baking tests. Clark (1929), Geddes and Winkler (1930), Swanson and Kroecker (1932), Blish and Hughes (1932) have all studied this problem. The change in loaf volume with the fermentation time has often been used as a measure of fermentation response. In this connection (*cf.* Working, 1929) it is interesting to consider for a moment certain relationships involved in the baking process. A rough

estimate may be made of the contribution of various factors to the final volume of the loaf. It is very convenient to use the specific loaf volume concept of Harrell (1929), that is, volume per 100 grams of flour. (See Table I.)

TABLE I
CONTRIBUTIONS TO SPECIFIC LOAF VOLUME

	cc. per 100 gms. of flour (approximate)
<i>Proof volume</i>	
Dough ingredients	± 160
CO ₂ at 30° C. (Average proof)	± 300
<i>Expansion only</i>	
Increase in volume of CO ₂ , including increase in aque- ous tension	± 110
Decrease in solubility of CO ₂	± 30
Increased fermentation rate	± 60
	<hr/> ± 660

The interesting question arises as to the limit of this figure. Bailey and collaborators (1918 to date) have measured the maximum dough volume at the beginning of fermentation in a special fermenting jar. Under these conditions values in the neighborhood of 450 cc. have been obtained for the maximum dough volume. This represents the initial value with zero fermentation at the beginning of the measurement. However, it is well recognized that handling of the dough, particularly after a small amount of fermentation has taken place, has a marked effect upon the volume which can be obtained. The process of punching, dividing, rounding and moulding, brings the dough to a condition in which larger volume is possible. Thus specific loaf volumes of 700 cc. are not uncommon. Again it is interesting in this case to determine what fraction of the possible maximum volume this represents. Accordingly, the technique described by Bailey and Johnson (1924) has been adapted to the measurement of the maximum dough volume in the pan.

Methods

Heretofore it has been the usual practice to use straight doughs in experiments of this nature (Figure 3). However, as has been shown by a number of investigators, it is more difficult to control the fermentation and sugar level during the critical proof period in straight doughs than it is in sponges. In order to remove this factor from the study the policy of using 90% sponges was adopted. In addition, since it has been shown elsewhere (Landis and Frey, 1933) that non-diastatic malt

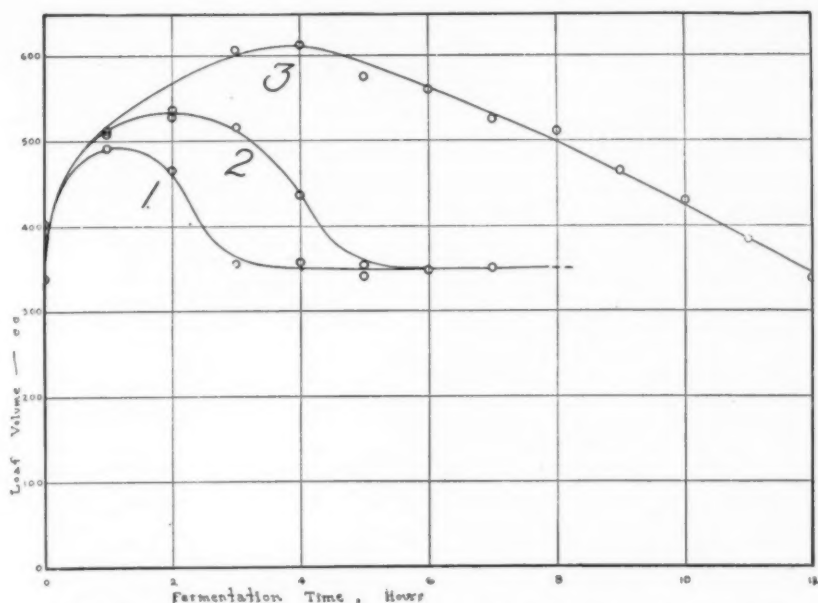


Fig. 3. Fermentation response in straight doughs (after Blish and Hughes, 1932). (1) 0% sugar, (2) 2½% sugar, (3) 10% sugar. The drastic effect of sugar shortage is readily distinguishable from true fermentation response (3).

at once stabilizes the fermentation and supplements the diastatic capacity, this ingredient was used in place of sugar. Results with sucrose were in general quite similar but slightly irregular. In general, a formula closely approximating the following was used:

(100% = 100 grams)

Sponge
 Flour90%
 WaterVariable
 Yeast3%
 Non-diastatic malt—Variable, to suit test

Dough
 Flour10%
 WaterVariable
 Salt1%
 Non-diastatic malt5-8%
 ShorteningNone

The factor of consistency was eliminated as far as possible by varying the absorption to suit the flour and the amount of sugar to be fermented. Each sponge and dough was subjected to exactly the same mechanical handling, being mixed for three minutes, allowed to ferment until the required amount of sugar was converted, the dough ingredients added, and the sponge and dough mixed again for three minutes. No intermediate punching was performed. Thus the volume obtained should reflect accurately the response of the flour colloids under these conditions to fermentation. After the second mixing the doughs were divided into convenient aliquots, *e.g.* 50, 75, and 100 grams (flour) and tests made upon each.

The results obtained by this method are shown in Figure 4. In order to observe the changes which occurred in the response curves as the loaf was made to approach the maximum dough volume, doughs of different sizes were baked in the standard A. A. C. C. baking test pans. These doughs were proofed to constant volume, thus minimizing the effect of small variations in fermentation characteristics. One panned dough from each series was placed in a tight jar and the maximum volume determined by means of the automatic expansion recorder, using essentially the technique described by Bailey and Johnson (1924). The curves are of the general form which has been previously determined by

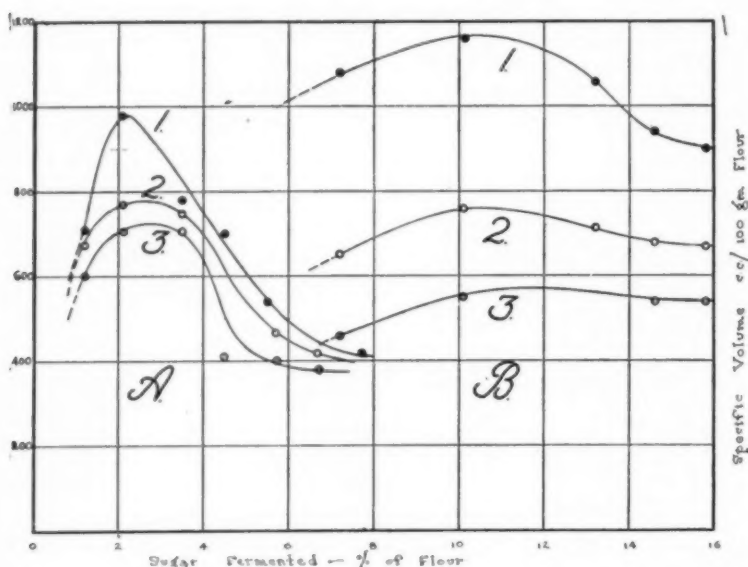


Fig. 4. Fermentation response at different characteristic loaf volumes. A. Soft patent flour (in commercial pans), B. Northwestern patent flour (in standard test pans). (1) Specific maximum (panned) dough volume, (2) Loaf volume at 60-80% characteristic volume, (3) Loaf volume at 40-45% characteristic volume.

other methods, but the irregularities are somewhat less apparent. It is particularly worthy of note that as the loaf volume approaches the maximum dough volume the differences observed are accentuated. Thus loaves baked by the normal procedure which results in a final loaf volume far below that of the maximum dough volume (40% to 45%) show but little variation between the extremes of fermented sugar, while loaves containing 50 grams of flour which give a volume from 60% to 80% of the maximum dough volume show much greater but still regular variations. Thus it appears that fermentation response and probably other responses as well may be measured with greater accuracy by

allowing the loaf volume to approach the maximum dough volume (Figure 4). It also seems apparent that the determination of maximum dough volume is a good test of a flour's strength, but it must be determined over a range of values of fermented sugar to find what and where the maximum is. The alternative is to bake at or near the maximum dough volume. Actual practical application of this method of procedure also should lead to the ability to tell at what specific volume or fraction of the maximum dough volume¹ texture is adversely affected.

Summary

The effect of fermentation upon the flour colloids has been followed by: (a) Qualitative methods such as tactual observation and mechanical handling characteristics; (b) physical and chemical methods such as peptization, plasticity, and viscosity; and (c) practical baking methods, such as the determination of maximum dough volume and loaf volume.

In order to determine this change by baking methods it is necessary that variations in all other factors, such as sugar level, nitrogen level, fermentation characteristics, mechanical handling, and proof volumes be minimized.

A modification of the basic procedure (short method) which serves in a large measure to minimize variations in these factors is described. The essential changes are: (a) The use of 90% sponges; (b) supplementing the diastatic level with non-diastatic malt; (c) baking at a volume approaching that of the maximum dough volume.

The maximum dough volume has been found to change in a regular manner with the amount of fermentation. The loaf volume obtained under the same conditions reflects this change in a degree roughly comparable to the fraction of the maximum dough volume (termed characteristic loaf volume) at which the loaves were baked. Loaves baked at normal characteristic volumes (40% to 45%) frequently show but slight fermentation response.

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¹ Expressed as percent this fraction has been termed the "characteristic loaf volume."

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TEMPERATURE CONTROL IN THE BAKING TEST WITH REVOLVING SHELVES IN PROOFING CABINET ¹

W. O. WHITCOMB

(Presented at the Annual Meeting, June, 1934)

Temperature control in the baking test is one of the most important features in securing uniform results. This feature of the baking test has received special attention at the Montana Agricultural Experiment Station during the past three or four years. The principle of the revolving shelves in the baking oven, which has been used successfully for the past several years, suggested the use of revolving shelves in the proofing cabinet. In 1932, a cabinet having revolving shelves was constructed in a local shop and has been in constant use since that time in the Montana Grain Inspection Laboratory.

Construction of Proofing Cabinet with Revolving Shelves

As shown in Figure 1, the cabinet has three compartments, two of which are equipped with revolving shelves for the fermentation and proofing of dough, while the third one is used as a warming closet.

The outside dimensions of the cabinet are 5'1" long x 2'8" high x 1'4" deep. Compartments 1 and 2 are each equipped with three shelves. Each shelf provides space for four doughs, thus making the capacity of the cabinet twenty-four doughs. These shelves are securely fastened to a vertical shaft which revolves in wooden bearings and is fitted with a grooved pulley at the top. The front panel of each compartment is fitted with three small doors having double glass which prevents the surface of the glass on the interior of the cabinet from fogging over and obscuring the vision. These doors are so situated as to provide an individual opening for each shelf.

The heating units consist of strips of asbestos board wound with No. 30 chromel wire, and are controlled with a thermo-regulator in each compartment. In addition to these heating units, each compartment is equipped with two electric light bulbs. One of these bulbs is on constant heat and is immersed in water to provide humidity. The other bulb is on thermostatic control and is used as a source of heat during the night. When the cabinet was originally constructed, a 25 watt bulb was used for the constant heat and for humidification, but it was later found that

¹ Contribution from the Montana Grain Inspection Laboratory, Agricultural Experiment Station, Montana State College, Bozeman, Paper No. 44, Journal Series.

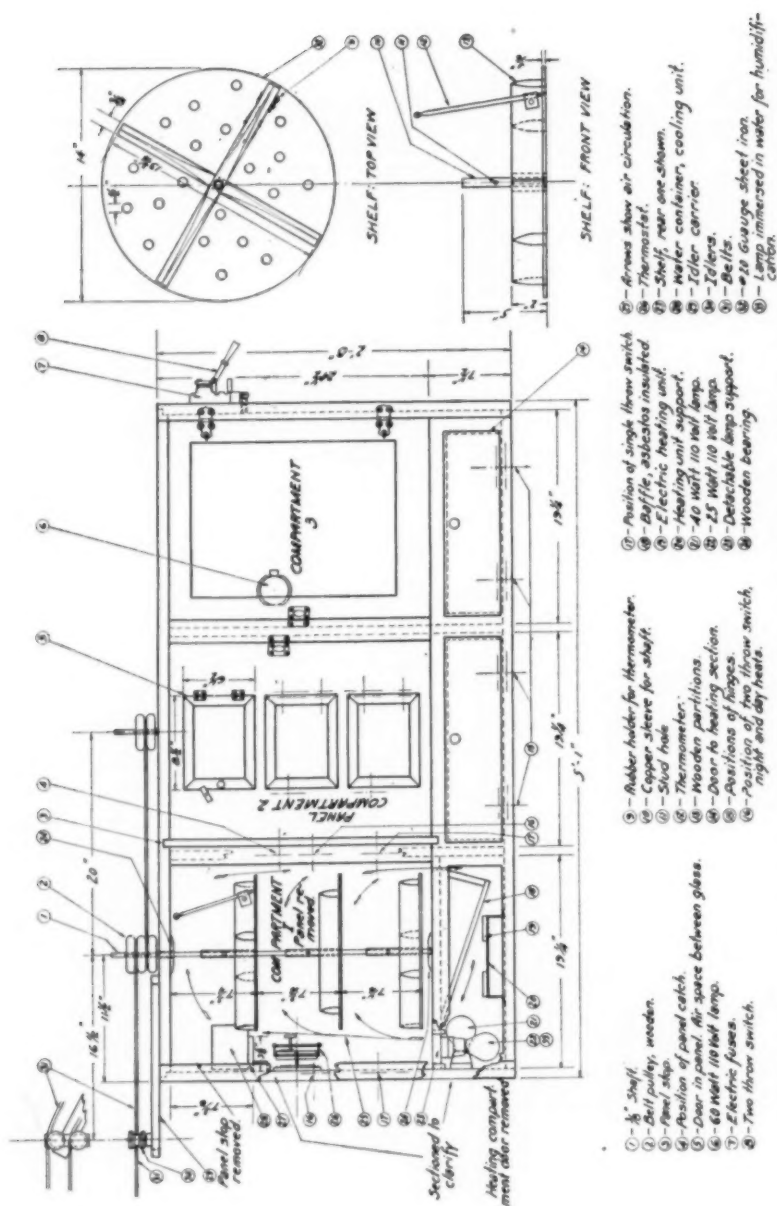


Fig. 1. Fermentation and proofing cabinet for experimental baking test. The shelves revolve at the rate of two times per minute. The capacity of compartments 1 and 2 combined is twenty-four doughs.

a 15 watt bulb was better adapted for this purpose. It has also been found that a 25 or 40 watt bulb on thermostatic control can be substituted for the more complicated heating units. Thermometers are so located on each of the revolving shelves that they may be read to the nearest half degree as they pass by the doors.

The cooling system consists of two cans of cold water placed on stationary shelves near the top of each compartment. This system prevents the temperature of the cabinet from exceeding 30° C. even though the temperature of the room may approach that temperature.

The power for revolving the shelves is furnished by a system of reduction gears driven by a $\frac{1}{20}$ h.p. motor. Small round leather belts are used to transmit the power to the shafts which support the shelves. The speed of the shelves is regulated by varying the size of the pulleys. The most satisfactory speed has been found to be two revolutions per minute. This power system is also used for revolving the shelves in the baking oven.

This proofing cabinet differs from that described by Larmour, Machon, and Brockington (1931) in the following essentials: (1) Shelves are revolving constantly at the rate of two times per minute as compared with rotation by hand at certain intervals; (2) doors are small and one door serves each shelf as compared with a large door which exposes the entire front of the compartment; (3) no ventilation is provided as compared with vents in the rear wall; (4) constant heat and humidification are provided by one and the same electric light bulb in water as compared with water exposed in shallow pans in air current and a small cigar-case humidifier; (5) the thermo-regulator is located midway between the top and the bottom of the compartment as compared with location at top; and (6) the same compartment is used for both fermentation and proofing as compared with separate compartments for these purposes.

A comparison of this cabinet having revolving shelves with the one having stationary shelves as designed by Bailey (1930) shows the following points of difference: (1) The circulation of the air of the interior of the cabinet is effected by the moving shelves and the dishes containing the dough as compared with circulation by means of fan; (2) humidity is provided by electric light bulb in water as compared with wicks in water and Bahnson humidifier; (3) a cooling system is provided by cans of cold water as compared with ice or special cooling coils; (4) the compartments are small, thus facilitating the control of temperature and humidity as compared with one large compartment; and (5) precooling of the cabinet before using each day is not necessary as compared with a special provision for this.

Operation of Cabinet

Two years of practical use of this cabinet with revolving shelves has demonstrated its adaptability to the proper fermentation and proofing of dough for the Standard Experimental Baking Test as outlined by Blish (1928). The possible injurious effect on the fermenting dough of the vibration of the shelves due to the constant motion was given special consideration. It was found that the shelves, which are securely attached to the vertical shaft which is slowly revolved by means of a light belt, move smoothly and that there is no appreciable vibration. The ease of quickly locating the various pans of dough was at first questioned. It was found in practice, however, that the numbers on the various sections on each shelf facilitated the location of each dough and the return of it to its proper place so that actually no difficulty was experienced.

As a means of testing the practical value of the principle of the revolving shelves in the fermentation and proofing cabinet, a special study was made of the humidity and temperature of the cabinet during the baking test. The humidity of the air surrounding the dough was found to be of the proper degree as judged by the appearance of the surface of the dough. The dough was found to be moist at all times but not sticky when the 15 watt bulb was submerged in the water. The temperature of this water was found to approximate 50° C. A special study of the temperature of the air in the cabinet and of the dough during the test was made.

Temperature of Cabinet During Operation

Temperature readings were made with thermometers which revolve with the shelves. One thermometer is located in a semi-vertical position near the edge of each shelf, thus making the scale visible through the glass door. Frequent readings made during the operation of the cabinet showed that the temperature seldom varied more than 0.5° C. from the prescribed 30 C°. When the shelves were allowed to remain stationary, as was the case overnight, a variation of one degree or more on different shelves in the same compartment was noted, but when the shelves were set in motion, the temperature was soon equalized. A typical set of temperature readings of the two compartments of the cabinet is shown in Table I. It will be observed that the temperature on two shelves was 31° C. at the time the shelves were started rotating, but that the temperature of the various parts of the cabinet was soon equalized.

TABLE I
TEMPERATURE OF PROOFING CABINET DURING THE BAKING TEST¹

Time	Compartment No. 1			Compartment No. 2		
	Shelf number			Shelf number		
	1	2	3	1	2	3
	° C.	° C.	° C.	° C.	° C.	° C.
8:10	30.0	30.5	30.0	30.0	31.0	31.0
9:00	29.5	30.0	29.5	30.0	30.0	30.0
9:30	30.0	30.0	30.0	30.5	30.5	30.0
10:00	30.5	30.5	30.0	30.5	30.5	30.0
10:30	30.0	30.0	30.0	30.0	30.0	30.0
11:00	30.0	30.0	30.0	30.0	30.0	30.0
11:30	30.0	30.0	30.0	30.0	30.0	30.0
12:30	30.0	30.0	30.0	30.0	30.0	30.0
1:50	30.0	30.0	30.0	30.0	30.0	30.0

¹ Date of test, April 7, 1934.

Temperature of Flour, Solutions, and the Resulting Dough During the Baking Test

A uniform temperature of 30° C. (plus or minus 0.5°) for the dough has been prescribed for the Standard Experimental Baking Test. Experience has shown that special equipment and careful manipulation of the dough are necessary for the attainment of this standard.

The proper control of the temperature of the room, and of the ingredients which constitute the dough, will assure the desired results as to the temperature of the dough as mixed. It has been found that for best results the temperature of the room should be maintained at from 23° to 25° C. At this room temperature, the following temperatures of ingredients produced a dough having a temperature of 30° C. (plus or minus 0.5° C.) when mixed one and one-half minutes and folded ten times: Flour, 29.5°; yeast in water, 31.0°; sugar-salt solution, 45.0°; and water 45.0°. In practice it was found desirable to combine the above solutions before adding them to the flour in the mixing bowl. When these solutions were combined under the above temperature conditions, the temperature of the resulting mixture was found to be 34° C. (plus or minus 0.5° C.).

To insure the above temperature conditions of the ingredients of the dough, it has been found desirable to place the weighed quantities of the flours in the fermentation bowls the day before the baking test. These bowls are covered and placed in the fermentation cabinet at 30° C. and allowed to remain overnight. It is well to place a can of warm water near the source of heat to insure proper humidity conditions for starting the baking test. The sugar-salt solution is also made up during the day previous to baking and placed in a warming cabinet at 45° to

47° C. A bottle of water for adjusting the absorption of the various flours is also placed in this cabinet. The yeast is placed in water and allowed to stand overnight in a cooler, after which it is warmed in a pan of water to 31° C. and placed in a cabinet at about 32° C.

Temperature readings of the dough as mixed, together with the same readings on the dough after it had received the first and second punches, and also just before it was panned, are given in Table II. The

TABLE II
TEMPERATURE OF FLOUR, SOLUTIONS, AND THE RESULTING DOUGH DURING THE BAKING TEST¹

Sample number	Time mixed	Room	Flour	Com-bined solutions	Dough mixture	Dough 1st punch	Dough 2nd punch	Dough panned
		° C.	° C.	° C.	° C.	° C.	° C.	° C.
1	8:10	24.5	30.5	34.5	30.5	30.0	30.0	30.0
2	20	24.0	30.5	34.0	30.0	30.0	30.0	30.0
3	30	23.0	30.0	34.0	29.5	30.0	30.0	29.5
4	40	23.5	30.0	34.0	29.5	30.0	30.0	29.5
5	50	23.5	29.5	34.0	29.5	30.0	30.0	29.5
6	9:00	23.5	29.5	34.0	29.5	30.0	30.0	29.5
7	10	23.5	30.0	34.0	29.5	30.0	30.0	29.5
8	20	24.0	30.0	34.0	30.0	30.5	30.0	30.0
9	30	24.0	30.0	34.0	30.0	30.0	30.0	30.0
10	40	24.0	30.0	34.0	30.0	30.0	30.0	29.5
11	50	24.5	30.0	34.0	30.0	30.0	29.5	30.0
12	10:00	24.5	30.0	34.0	30.0	29.5	29.5	30.0
13	10	24.5	30.0	34.0	30.0	30.0	30.0	30.0
14	20	25.0	30.0	34.0	30.0	29.5	30.0	30.0
15	30	24.0	30.0	34.0	29.5	30.0	30.0	30.0
16	40	24.0	29.5	34.0	29.5	30.0	29.5	30.0
17	50	24.0	30.0	34.0	30.0	30.0	29.5	30.0
18	11:00	24.5	29.0	34.5	29.5	29.5	29.5	30.0
19	10	24.0	29.5	34.5	29.5	29.5	29.5	30.0
20	20	24.0	29.5	35.0	30.0	29.5	30.0	30.0
21	30	24.0	30.0	34.0	29.5	30.0	30.0	30.0
22	40	24.0	29.5	34.5	30.0	30.0	30.0	30.0
23	50	24.0	29.0	34.5	30.0	30.0	30.0	30.0
24	12:00	24.0	29.5	34.5	29.5	30.0	30.0	30.0

¹ Date of test, April 7, 1934.

dough was given the first and second punches and prepared for the pan by passing it through a pair of sheeting rolls. These rolls are covered with canvas and are power-driven. Readings taken on the dough before and after passing through the sheeting rolls showed that the temperature did not change more than one-half of a degree.

Summary

It has been found possible to maintain the temperature of the dough during the baking test from the time it is mixed until it is placed in the oven at a temperature of 30° C. (plus or minus 0.5° C.). The

temperature of the room, the temperature of the ingredients, and the temperature of the cabinet must be carefully controlled to attain this standard. The construction of a fermentation and proofing cabinet having shelves which revolve at a uniform rate of two times per minute has done much to make possible this temperature control of the dough.

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REPORT OF THE COMMITTEE ON TESTING RYE FLOUR

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(Presented at the Annual Meeting, June, 1934)

Following the recommendations of last year's committee, the first work undertaken this year was to design a score card for scoring rye breads. This was not a simple task. There are at least five recognized grades of rye flour, *viz.*, white, light, medium, dark, and extra dark. Rye bread as such is never made with rye flour alone, but is mixed with clear and/or other grades of wheat flour, in proportions varying from 5% to 50%. The character of the bread made from these various mixtures consequently is anything but uniform.

The question arises, therefore, whether it is possible to use one score card to score all the various types of rye bread. The committee believes that it is possible to use the same score card with the understanding that each class of rye bread shall be considered by itself, *i.e.*, white rye by itself, medium rye by itself, and dark rye by itself.

The committee has drawn up a tentative score card for consideration. This card has the usual headings—volume, general appearance, crust color, grain, texture, crumb color, odor, and taste, and in addition has added specific gravity. Of course there is a direct relation between volume and specific gravity and whether this item will be retained is still an open question. It has been noticed in some experimental work that the best scores were always given to those loaves that had the lowest specific gravity and hence this determination was included.

Each of the usual points to be considered was assigned an arbitrary numerical value to be given to the loaf that was perfect in that particular

characteristic. The sum of these numerical values equals 100. It was believed that small differences in breads could be better shown by numbers than by descriptive terms. It is understood that a descriptive term may be used in connection with a number to explain the score thus 10y under crumb color means that the score was low on crumb color because it was too yellow. The technician, scoring bread, must have an ideal loaf in mind before he can assign values to the different characteristics under consideration. This is true whether he expresses his opinion in a descriptive term or in a number. The committee is proposing this numerical score card for trial and consideration.

Tentative methods have been drawn up for making the three principal types of rye bread, *viz.*, white rye, medium rye, and dark rye. In order to have loaves that would be somewhat alike the following proportions of rye flour to clear flour were used—white rye to clear 1:1, medium rye to clear 1:2 and dark rye to clear 1:4. The formulae, and fermentation and proofing periods follow.

White rye bread

Clear flour 100 gms.
White rye flour 100 gms.
Yeast 5 gms.
Salt 3 gms.
Water sufficient
Mix for 3 minutes in
Hobart-Swanson mixer
1st punch 75 min.
2nd punch 45 min.
Mold 30 min.
Proof 45 min.

Medium rye bread

Clear flour 133 gms.
Medium rye flour 67 gms.
Yeast 5 gms.
Salt 3 gms.
Water sufficient
Mix for 3 minutes in
Hobart-Swanson mixer
1st punch 75 min.
2nd punch 45 min.
Mold 30 min.
Proof 45 min.

Dark rye bread

Clear flour 160 gms.
Dark rye flour 40 gms.
Yeast 5 gms.
Salt 3 gms.
Water sufficient
Mix for 3 minutes in
Hobart-Swanson mixer
Punch 75 min.
Mold 45 min.
Proof 25-30 min.

Add plenty of steam or brush loaves with water two or three times after the crust has formed. Bake at 230° C. for 30 to 35 minutes. Allow the bread to cool thoroughly before scoring. The scoring may be done the following day if more convenient. A uniform scoring time should be adopted.

The committee members individually and collaboratively made numerous baking tests which were used in developing these methods and the proposed score card. For the collaborative work each member had 14 samples of rye flour. There were 4 samples of white rye and 2 samples of white rye blended with small quantities of dark rye, also 4 samples each of the medium and dark rye flours. These samples were furnished by four rye mills, all located in the Middle Northwest Section of the United States. All the samples were commercial runs except the blends. Blend No. 1 had 2½% dark rye, blend No. 2 had 5% of dark rye admixed with the white rye. These collaborative samples were baked by each member of the committee and the scores submitted to the chairman who summarized them.

In the summary the rye flours were labelled A, B, C, and D for each of the three grades of white, medium, and dark. The flours marked A all came from the same mill, those marked B from another mill, and so on.

TABLE I
SCORES OF COLLABORATIVE BAKING OF RYE FLOURS
(White rye flour 50—clear flour 50)

Collaborator	Sample	Sp. gr.	Volume	General appearance	Crust color	Grain	Texture	Crumb color	Odor and taste	Remarks
			20	15	5	10	10	15	25	
Flohil	A	0.36	17.5	13.0	3.5	6.5	7.5	13.0	22.0	P = Pale G = Grey
Sanford	"	.32	17.0	14.0	4.0 P	9.0	10.0	14.0	25.0	
Epstein	"	—	15.0	13.0	4.0	8.0	9.0	14. G	25.0	
Moen	"	.31	17.4	12.0	3.0	9.0	9.0	13.0	23.0	
Bailey	"	.43	15.0	10.7	3.6	8.2	7.9	13.6	22.8	
Flohil	B	.35	18.0	13.0	4.0	8.0	8.5	13.0	20.0	
Sanford	"	.28	20.0	14.0	5.0	9.0	10.0	14.0	25.0	
Epstein	"	—	18.0	15.0	5.0	8.0	10.0	13. G	25.0	
Moen	"	.31	17.3	12.0	3.0	9.0	9.0	13.0	22.0	
Bailey	"	.41	15.6	12.0	4.0	8.8	8.5	13.4	23.4	
Flohil	C	.36	18.0	12.0	4.5	7.5	9.0	13.5	23.0	
Sanford	"	.27	20.0	15.0	5.0	9.0	10.0	14.0	25.0	
Epstein	"	—	19.0	15.0	5.0	9.0	10.0	15. G	25.0	
Moen	"	.28	18.9	13.0	3.0	9.0	9.0	14.0	23.0	
Bailey	"	.36	18.0	12.2	4.5	8.5	8.9	13.1	23.0	
Flohil	D	0.38	17.5	12.0	4.0	8.0	9.0	12.5	22.0	
Sanford	"	.28	19.5	15.0	5.0	9.0	10.0	14.0	25.0	
Epstein	"	—	16.0	15.0	5.0	9.0	10.0	14. G	25.0	
Moen	"	.29	17.8	12.0	3.0	9.0	9.0	13.0	23.0	
Bailey	"	.39	16.3	12.3	4.0	9.0	8.6	13.0	23.0	
Flohil	Blend no.1	.38	17.0	11.0	3.5	7.5	8.0	12.5	23.0	
Sanford	"	.29	19.0	14.0	5.0	9.0	10.0	13.0	25.0	
Epstein	"	—	—	—	—	—	—	—	—	
Moen	"	.30	17.4	12.0	3.0	9.0	9.0	11.0	23.0	
Bailey	"	.42	15.3	12.5	3.7	8.6	8.3	12.7	23.8	
Flohil	Blend no.2	.36	17.5	11.0	3.5	7.5	9.0	12.0	21.0	
Sanford	"	.30	18.5	13.0	5.0	9.0	10.0	12.0	25.0	
Epstein	"	—	—	—	—	—	—	—	—	
Moen	"	.30	17.6	12.0	3.0	9.0	9.0	11.0	23.0	
Bailey	"	.41	15.5	12.6	3.8	8.9	8.2	12.3	23.9	

A study of Tables I, II, and III discloses that the personal equation has entered into these results. Whether the differences are due to environmental conditions of baking, to different ideals of the perfect loaf

held by the different collaborators, or to some other cause has not been determined. Nevertheless the results are close enough to make it worthwhile to continue the study.

Recommendations for future study include variations in length of mixing time, in the number of punches, the length of fermentation and proof.

TABLE II
SCORES OF COLLABORATIVE BAKING OF RYE FLOURS
(Medium rye flour 33 $\frac{1}{4}$ —clear flour 66 $\frac{2}{3}$)

Collaborator	Sample	Sp. gr.	Volume	General appearance	Crust color	Grain	Texture	Crumb color	Odor and taste	Remarks
			20	15	5	10	10	15	25	
Flohil	A	0.35	17.0	12.0	4.5	8.0	8.0	12.5	20.0	Sly = slightly yellow
Sanford	"	.29	20.0	15.0	5.0	10.0	10.0	14.0	25.0	
Epstein	"	—	(18.9)	15.0	5.0	10.0	10.0	15.0	25.0	
Moen	"	.26	18.2	14.0	5.0	9.0	9.0	13 Sly	23.0	
Bailey	"	.36	17.5	12.5	4.5	8.3	9.0	13.0	24.0	
Flohil	B	.35	17.0	12.0	4.5	7.5	9.0	13.5	22.0	y = yellow
Sanford	"	.28	20.0	14.0	5.0	10.0	10.0	13. y	25.0	
Epstein	"	—	(18.3)	15.0	5.0	10.0	10.0	14.0	25.0	
Moen	"	.26	18.5	14.0	5.0	9.0	9.0	10. y	22.0	
Bailey	"	.37	17.0	12.8	4.3	9.0	9.0	12.8	24.0	
Flohil	C	.33	18.0	13.0	4.5	7.5	9.0	14.0	21.0	
Sanford	"	.28	20.0	14.0	5.0	9.0	10.0	14.0	25.0	
Epstein	"	—	(19.3)	15.0	5.0	10.0	10.0	15.0	25.0	
Moen	"	.26	18.6	14.0	5.0	9.0	9.0	14.0	23.0	
Bailey	"	.38	17.0	13.0	4.2	8.5	8.8	12.5	24.0	
Flohil	D	.33	18.0	12.0	4.0	7.5	8.5	13.5	21.0	
Sanford	"	.29	20.0	14.0	5.0	9.0	10.0	13.0	25.0	
Epstein	"	—	(17.8)	15.0	5.0	9.0	9.0	15.0	25.0	
Moen	"	.26	18.3	14.0	5.0	9.0	9.0	13.0	23.0	
Bailey	"	.36	16.2	12.5	4.1	8.9	8.6	13.0	23.8	

Should the highest score be given to the lightest crumb color or the darkest color within the same grade?

Should an open grain or a close grain within the same grade be scored the higher?

Consideration should be given to the feasibility of preparing photographs showing characteristics externally and internally of different classes of rye breads, and even showing differences that may be expected

TABLE III
SCORES OF COLLABORATIVE BAKING OF RYE FLOURS
(Dark rye flour 20—Clear flour 80)

Collaborator	Sam- ple	Sp. gr.	Vol- ume	Gen- eral ap- pear- ance	Crust color	Grain	Tex- ture	Crumb color	Odor and taste	Remarks
			20	15	5	10	10	15	25	
Flohil	A	0.32	18.0	13.0	4.5	8.0	9.0	13.0	21.0	Too light
Sanford	"	.27	20.0	15.0	5.0	9.0	10.0	T. L. 11.0	25.0	Mixed and proofed same as white rye
Epstein	"	—	(16.8)	15.0	5.0	10.0	10.0	15.0	25.0	Very light
Moen	"	.29	18.6	15.0	5.0	10.0	10.0	9.0	23.0	
Bailey	"	.31	20.0	12.0	4.0	8.5	8.5	V. Lt. 12.3	23.0	
Flohil	B	.40	17.0	13.0	4.5	8.0	8.0	14.0	20.0	Mixed and proofed same as white rye
Sanford	"	.29	20.0	14.0	5.0	9.0	10.0	12.0	25.0	
Epstein	"	—	(17.0)	15.0	5.0	10.0	10.0	15.0	25.0	Light yellow
Moen	"	.28	18.8	15.0	5.0	10.0	10.0	9.0	23.0	
Bailey	"	.32	19.0	11.0	4.0	8.0	8.0 Op.	Lt. y. 12.5	22.0	Open
Flohil	C	.39	17.0	13.0	4.5	7.5	9.0	12.0	20.0	Dirty grey
Sanford	"	.29	19.0	14.0	5.0	9.0	10.0	D. G. 13.5	25.0	Mixed and proofed same as white rye
Epstein	"	—	(16.5)	15.0	5.0	10.0	10.0	15.0	15.0	Light
Moen	"	.28	18.8	15.0	5.0	10.0	10.0	11.0	23.0	
Bailey	"	.37	15.5	12.5	4.0	9.0	9.0	Lt. 12.8	24.0	
Flohil	D	.38	17.0	12.0	4.0	7.5	8.5	12.0	22.0	Too brown
Sanford	"	.28	20.0	14.0	5.0	9.0	10.0	T. B. 15.0	25.0	Mixed and proofed same as white rye
Epstein	"	—	(16.0)	14.0	5.0	10.0	10.0	15.0	25.0	Very dark, very strong
Moen	"	.29	18.1	15.0	5.0	10.0	10.0	V. D. 13.0	V. S. 23.0	
Bailey	"	.35	16.0	11.8	4.0	8.8	8.8	13.0	23.0	

within the same classes. Such a group of photographs would necessitate much careful work but if done would be a great help in scoring similar rye breads.

SOME OBSERVATIONS ON THE USE OF SELENIUM AND ITS COMPOUNDS AS A CATALYST IN THE DETERMINATION OF PROTEIN IN WHEAT BY THE KJELDAHL METHOD

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Introduction

Any method, device or reagent which will materially shorten the time necessary to make a protein determination commensurate with a high degree of accuracy is of outstanding interest to the cereal chemist. Thus, when Lauro (1931) proposed the use of selenium and some of its compounds as a substitute for mercury and/or other catalysts in the Kjeldahl method on the grounds (1) that the time of digestion could be materially shortened, (2) that the cost of the protein determination would be reduced by savings on fuel and chemicals, and (3) that accuracy was not disturbed, his recommendations were tried by a number of cereal chemists among whom Rich (1932), Sandstedt (1932), Messman (1932), and Osborne (1933) report favorable results. Crossley, Tennant *et al.*, and West and Brandon, working with coal and biological materials, are cited by Lauro (1933) as reporting results supporting the claim that marked savings in operative costs, as well as distinct reductions in time of analysis result from the use of selenium or its salts.

Anyone who has had the experience of watching a Kjeldahl digestion when metallic selenium or one of its compounds is being used as one of the catalysts, can not but be amazed at the rapidity with which the digest clears. The violence of the reaction seems to increase in intensity as metallic selenium is replaced by its oxides, or oxychlorides. This phenomena may be accounted for, in part, it is believed, by the known corrosive action of some selenium compounds towards proteinaceous material— SeOCl_2 , for example.

On the other hand, the main reason for adding catalysts is to raise the boiling point of the sulphuric acid so that more optimum oxidative conditions are created. Other things being equal, the greater the intensity of heat, the more rapid should be the oxidation. This has been

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pointed out earlier by Coleman, Fellows, and Dixon (1926) in their study of methods for making protein tests on wheat.

The query arises, therefore, how much of the very rapid digestion phenomena experienced with selenium and its compounds is due to inherent oxidative properties, and how much may be ascribed to catalytic properties and/or heat effects.

It is the purpose of this paper to throw some light on these phases of the problem, and to determine in so far as possible whether selenium or some of its compounds, either singly or in combination with other catalysts, may be successfully used in determining the protein content of wheat and flour.

Experimental

Effect of Selenium and Its Compounds on the Temperature of Kjeldahl Digests

For the purpose of determining the effect of selenium and some of its compounds upon the temperature of Kjeldahl digestion mixtures, special Kjeldahl flasks and thermometers were devised. A small hole was blown into the cheek of a 500 cc. Kjeldahl flask, and a small glass tube attached so as to admit a thermometer. The thermometers were so drawn that they were a snug fit in the side tube and effectively precluded the escape of sulphur dioxide fumes during digestion, especially when the exhaust fan was in operation. The thermometers were prevented from reaching the bottom of the Kjeldahl flask by suspending from a tripod. They were scaled for 6-inch immersion (from the center of the 20 or 25 cc. layer of acid to the top of the glass tube) and calibrated from the 6-inch point from 300° C. to 500° C. in 2-degree intervals. New 500-watt Goldfish heaters of an accuracy of plus or minus 2% were used as the source of heat.

The temperatures recorded were the mean of several observations made at intervals of 5 minutes during the digestion period. Temperature observations were taken on five individual flasks. During the digestion a gentle suction was in operation induced by an exhaust fan located on the roof—75 feet away. The air passed through two right-angled bends in the exhaust passage. The intensity of fume evacuation is important because there is a direct relation between digestive gas removal and boiling point of the digestion mixture. High sulphur dioxide losses concentrate the acid with an increase in the boiling point of the reagents.

Series I

The first series of experiments were designed to study the effects of catalysts on the boiling point of sulphuric acid (sp. gr. 1.82), 20 cc.

of acid being used in each flask. The data are shown by means of curves in Figure 1. The weight and character of the catalysts studied are shown in the figure. The sulphuric acid maintained a boiling point of 345°C . The addition of 5 gms. of K_2SO_4 raised its boiling point to 354°C . at the end of 35 minutes; 10 gms. to 366°C ., and 15 gms. to 385°C . The addition of 0.5 gm. of red HgO to the 20 cc. of H_2SO_4 and 10 gms. of K_2SO_4 raised the boiling point to 368°C ., fourteen degrees above the boiling point of the sulphuric acid without the catalysts. With the addition of 1 gm. of sample, the temperature rose finally to

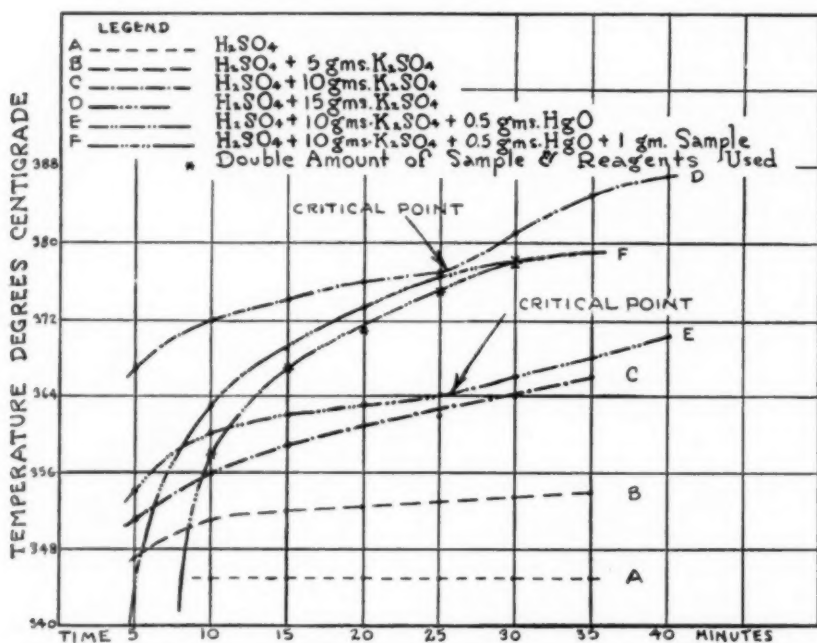


Fig. 1. The effect of K_2SO_4 and of K_2SO_4 and HgO on the temperature of the Kjeldahl digests.

379°C ., or 10°C . above the temperature of the boiling acid plus the two catalysts (10 gms. K_2SO_4 and 0.5 gm. red HgO). Doubling the weight of sample and reagents resulted in a more rapid increase in the temperature of the boiling acid mixture for a period of 25 minutes. After this period had passed, no greater increase than that obtained with half of the reagents was experienced.

In this series of tests, as well as in some of the tests to be described later, a break occurs in the temperature curves accompanied by a pronounced rise in temperature. This condition is illustrated by curve *D* in Figure 1. Tests to be recorded later support the view that digestion is complete at this point and that further digestion results in a loss of

nitrogen due to concentration of the digest. This phenomena is designated in the figures as the "critical point."

Series II

In Series II the effect of substituting varying quantities of metallic selenium for red HgO upon the boiling point of the standard Kjeldahl mix (20 cc. of H_2SO_4 Sp. gr. 1.82 + 10 gms. of K_2SO_4) was studied. The data are shown in Figure 2. The three lower curves show the

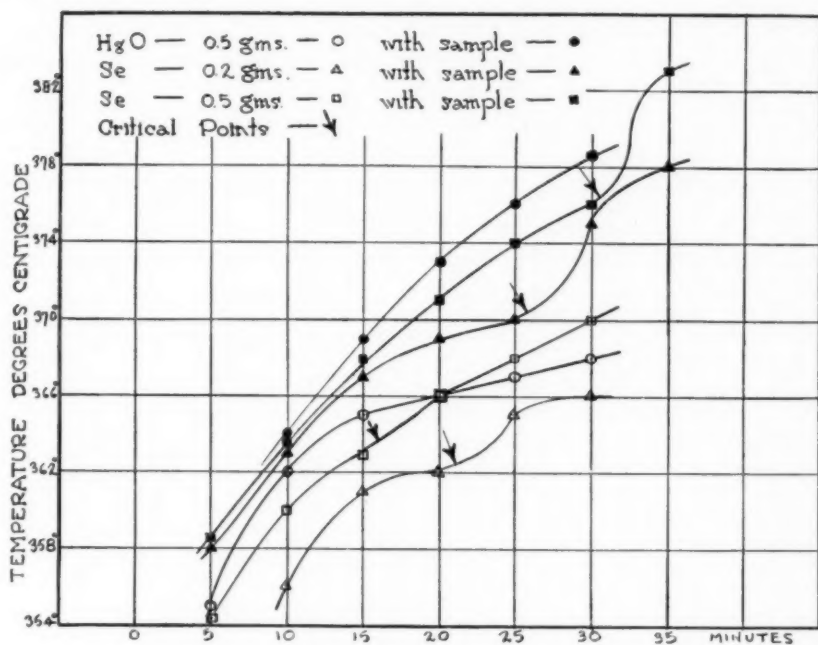


Fig. 2. The effect of selenium on the temperature of Kjeldahl digests.

effect on the temperature for the reagents without the sample and the three upper curves illustrate the effect when 1 gm. of sample was included.

It is quite clear that the use of 0.2 gm. of metallic selenium did not induce as high a temperature as did 0.5 gm. of HgO. This, in fact, is true at any point during the digestion period. The use of 0.5 gm. of Se increased the temperature somewhat as compared with 0.2 gm. of selenium and also as compared with 0.5 gm. of HgO although the effects as compared with the latter were somewhat slower in registering.

The same relations hold for the 0.2 gm. of Se when the 1 gm. sample is added, but do not hold for the other catalysts. Thus, as shown by the three upper curves in Figure 2, the greatest heat was developed with

0.5 gm. of HgO as one of the catalysts. Why this reversal in temperature effects takes place, when, as was shown in Figure 1, the oxidation of the sample results in an increase of heat, cannot, at the present writing, be explained.

It will be noted that the "critical point" occurs sooner when selenium is used as a catalyst. This argues for the point that digestion may be completed sooner than when red HgO is used; also, that the influence of selenium is probably catalytic in large measure, since, as has been pointed out above, lower digestion temperatures prevailed with both quantities of selenium. However, it is also reasonable to expect irregular tests if the flasks are not removed from the digester promptly after the "critical point" has been reached.

Series III

In Series III, the effect on temperature of using 0.2 cc. of SeOCl_2 in place of 0.5 gm. of red HgO was determined. The data are presented in Figure 3. Comparisons are made with and without the sample con-

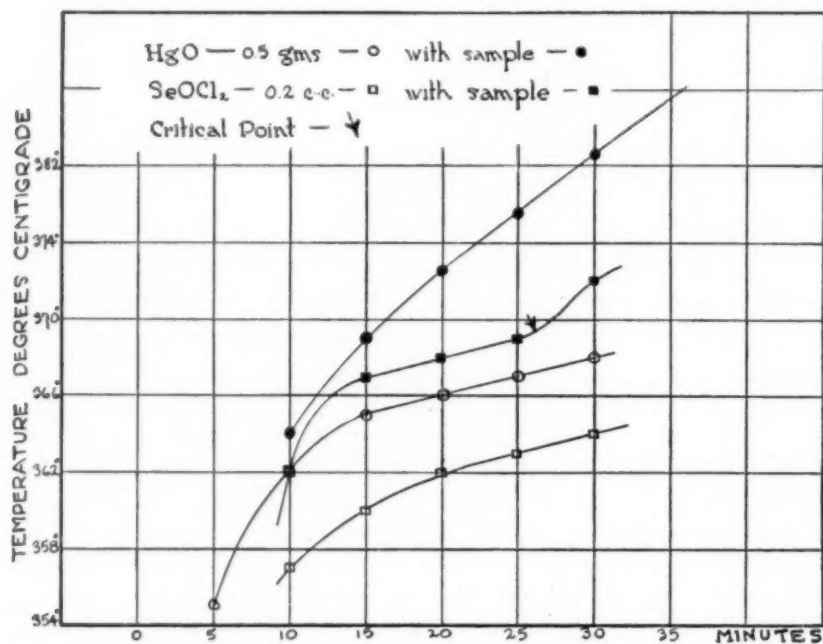


Fig. 3. The effect of SeOCl_2 on the temperature of Kjeldahl digests.

sisting of 1 gm. of wheat meal. It is clear from a study of the data that in so far as temperature effects are concerned, the red HgO was outstandingly the most effective both with and without the sample.

Series IV

The final series of observations with respect to temperature are shown in Figure 4. In this case the effect of 0.5 gm. of HgO was compared with that of 0.3 gm. of SeO_2 plus 0.05 gm. of metallic copper. As before, the tests were made with the chemicals only and with 1 gm. of wheat meal. Again the highest temperature was observed with the red oxide of mercury. The temperature curve resulting from the use of 0.3 gm. of SeO_2 and 0.05 gm. of Cu is more regular than that ob-

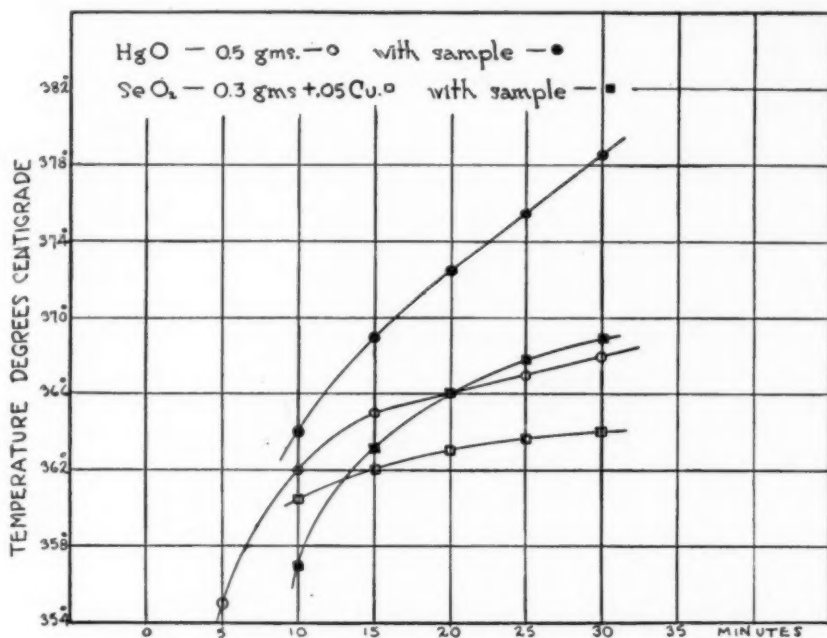


Fig. 4. The effect of SeO_2 on the temperature of Kjeldahl digests.

served when metallic selenium was used, suggesting less catalytic activity, but probably insuring against more erratic determinations.

General Observations

The more rapid clearing of the Kjeldahl digest in the presence of selenium and its compounds was outstanding. This cannot be accounted for entirely on the basis of temperature effects as, generally speaking, lower digestion temperatures prevailed than with red oxide of mercury. This situation leads immediately to the question as to whether complete conversion of the protein $(\text{NH}_4)_2\text{SO}_4$ has taken place; likewise whether nitrogen losses result when digestion proceeds beyond the so-called

"critical points." To answer these questions the analysis of a number of samples of wheat and flour by several different methods was undertaken.

Protein Determinations as Influenced by the Presence of Selenium and Some of Its Compounds³

In the first experiment eight samples of hard red winter wheat varying in protein content from 9.58% to 15.92% were selected and ground as finely as possible. The moisture contents were checked at each analysis interval and all results reported herein are on a 13.5% moisture basis. Samples of wheat were used in preference to flour as the non-uniformity of ground wheat exacts more precision in the determination for protein content.

In order to first determine with precision the protein content of the eight samples of wheat with which the subsequent selenium-Kjeldahl digestion studies were to be undertaken, several test runs were made. These included the standard method and others in which the digestion period was varied by 5-minute intervals from 15 minutes to 55 minutes. With the standard method, clearing of the digest was complete in approximately 12 minutes, with the burners at full heat. In all cases the protein determinations were made in replicates of eight (8); this number having been recommended by the Methods of Analysis Committee of the A. A. C. C. as necessary to reduce the error range in protein analyses on flour to 0.1%. Each determination as reported is therefore an average of eight determinations made in as nearly the same way as possible. Blank determinations were made with each sample, eight determinations and a blank constituting a series.

The standard method of analyses used was that described in United States Department of Agriculture Bulletin No. 1460. In brief, this method is as follows: 1 gm. of the finely divided wheat is digested with 20 cc. of concentrated H_2SO_4 (sp. gr. 1.82), 10 gms. of K_2SO_4 , and 0.5 gm. of red HgO for 30 minutes on 500-watt electric heaters (Goldfish) in a 500 cc. long neck Kjeldahl flask. At the end of the digestion period the flasks were cooled, diluted with 300 cc. of water, mossy zinc added and the solution neutralized with 75 cc. of NaOH , sp. gr. 1.45, containing 1 gm. of $\text{Na}_2\text{S}_2\text{O}_3$ per 75 cc. of alkali. The ammonia was distilled off into 10 cc. of 0.2N HCl diluted after placing in the flask with 50 cc. distilled H_2O and titrated with 0.1N KOH using methyl red as the indicator. $N \times 5.7$ was used to indicate protein content. Various catalysts, as well as various combinations of catalysts, were

³ The authors acknowledge with appreciation the assistance of Harry B. Dixon, of the Grain Division, Bureau of Agricultural Economics, who assisted with the protein determinations made in this study.

tried, as will develop from the discussion to follow. The results are given in Table I.

It is apparent that a digestion period of 30 minutes using the standard method was ample to convert all of the protein in wheat meal into ammonia. With even a 20-minute digestion period, the accuracy of the protein determinations was not seriously affected. After a 40-minute digestion period the results tend to become somewhat variable but there appears to be very little sacrifice in accuracy by allowing the digestion to proceed for 55 minutes.

TABLE I
PROTEIN RESULTS AS INFLUENCED BY TIME OF DIGESTION

Series number	Time	Crude protein content							
		Sample number							
		1	2	3	4	5	6	7	8
	Minutes	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.	P.ct.
I-A	15	9.43	10.11	11.02	11.90	12.55	13.98	14.36	15.70
I-B	20	9.42	10.20	11.11	11.98	12.58	14.03	14.41	15.74
I-C	25	9.50	10.20	11.05	12.00	12.50	14.02	14.45	15.88
I-D ¹	30	9.58	10.22	11.20	12.08	12.60	14.08	14.50	15.92
I-E	35	9.50	10.21	11.11	12.00	12.55	14.04	14.41	15.87
I-F	40	9.48	10.21	11.20	12.01	12.64	14.08	14.45	15.84
I-G	45	9.39	10.11	11.15	11.94	12.67	14.04	14.50	15.92
I-H	50	9.51	10.15	11.15	11.90	12.66	14.13	14.36	15.78
I-I	55	9.52	10.20	11.20	12.00	12.58	13.98	14.36	15.83

¹ Standard procedure.

A series of determinations was then made in which 0.1 gm. of selenium was substituted for the 0.5 gm. of red HgO in the standard formula. All other steps were the same.

It is perhaps needless to state that the mercury precipitant ($\text{Na}_2\text{S}_2\text{O}_3$) was eliminated from the concentrated NaOH before neutralizing the selenium K_2SO_4 digests. The digestion periods were varied from 15 to 30 minutes by 5-minute intervals. A longer digestion period was not used since the purpose was to ascertain whether by the use of selenium or its compounds a more rapid estimation of protein can be made than is the case with the present and reasonably satisfactory 30-minute digestion period using red HgO. Clearing of the digest with metallic selenium as one of the catalysts was approximately 40% faster, as the average time of clearing was 6 to 7 minutes, starting with the burners at full heat.

Attempts to distill away the ammonia resulting from the digests containing 0.1 gm. of Se were unsuccessful. Frothing was extreme

and a sufficient quantity of distillate could not be collected even after the introduction of paraffin. This extreme frothing was very unusual and is probably due to a reduction of the selenium compounds to metallic selenium with a subsequent deposition of the selenium on the mossy zinc and the development of a condition where air and gas bubbles are apt to collect under and about the surface of the mossy zinc. In a subsequent series of digests of the same character, glazed porcelain, glazed marbles, river soft stone, and pumice stone were used in place of the mossy zinc. All solutions bumped so violently during distillation that these procedures had to be abandoned. An attempt was made to solve this by reducing the specific gravity of the alkali from 1.45 to 1.22. With this modification bumping did not take place until approximately 100 cc. of distillate had accumulated. However, it was evident that the specific gravity of the alkali had been reduced too greatly as it was impossible to titrate the distillate because of an immediate fading of the end-point; a reddish-brown color returned and persisted in spite of the addition of more 0.1N KOH. Likewise, foul and disagreeable odors developed which soon filled the laboratory.

The fading of the end-point is not a new phenomena with us and frequently happens with methyl red indicator when insufficient neutralization has taken place and considerable hydrogen gas evolves. Hence it is not believed that selenium had any direct effect on this phenomena.

Trials were then continued replacing mossy zinc and the other ebullients with finely granulated zinc (30 mesh). Successful distillations were obtained. The results with this modification for the 25-minute digestion period are given in Table II. Although tests were made at the 15 and 20-minute intervals no averages are recorded due to lack of concordant results between replicates.

TABLE II
CRUDE PROTEIN DETERMINATIONS WITH 0.1 GM. OF SELENIUM COMPARED WITH THE
STANDARD METHOD

Method and time of digestion	Crude protein content							
	Sample number							
	1	2	3	4	5	6	7	8
	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>
Standard— 30-minute digestion	9.58	10.22	11.20	12.08	12.60	14.08	14.50	15.92
0.1 gm. Se replacing 0.5 gm. red HgO— 25-minute digestion	9.23	10.30	11.30	12.10	12.45	13.80	14.30	15.60

With but three exceptions, viz. samples 2, 3, and 4, significantly low percentages of protein were found in the samples when the 0.5 gm. of red oxide of mercury was replaced by 100 mgs. of Se.

The initial inability to distill Kjeldahl digests containing metallic selenium developed two significant facts: (1), that mossy zinc cannot be used as an ebullient with metallic selenium, and (2), in the presence of a slightly alkaline or an acid condition of the diluted digest offensive fumes develop suggestive of hydrogen selenide. This condition is probably brought about by nascent hydrogen acting on metallic selenium to form hydrogen selenide, some of which undoubtedly passed over into the distillate and was responsible for the disagreeable odors experienced. Such a situation creates a real health danger as in addition to the unpleasant pungent odor, characteristic of H_2Se , this gas is provocative of headaches, and it likewise affects the mucous membrane of the throat in such a way as to induce a form of catarrh.

The amount of selenium used in the digestion mixes was next increased to 250 mgs. and the digestion studies repeated. The results obtained are shown in Table III.

TABLE III
CRUDE PROTEIN DETERMINATIONS WITH 0.25 GM. OF SELENIUM COMPARED WITH THE STANDARD METHOD

Method and time of digestion	Crude protein content							
	Sample number							
	1	2	3	4	5	6	7	8
	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>
Standard— 30-minute digestion	9.58	10.22	11.20	12.08	12.60	14.08	14.50	15.92
0.25 gm. Se replacing 0.5 gm. HgO—25- minute digestion	9.32	9.82	11.04	11.85	12.43	13.83	14.31	15.59
30-minute digestion	9.42	10.04	10.93	11.84	12.42	13.74	14.31	15.55

The addition of two and one-half times the amount of selenium contributed very little towards improving the accuracy of the method. It can only be concluded from these studies that metallic selenium is not a suitable substitute for red oxide of mercury in the standard Kjeldahl digest when used for determining the crude protein content of wheat.

While the investigations described here were in progress, a request was received from the Chairman of the Methods of Analysis Committee

of the A. A. C. C. that an analysis for protein content be made of a sample of mill-run and straight-grade flour by the standard method using HgO in comparison with 0.075 gm. of selenium. However, a 45-minute digestion period for the standard method and a 45- and a 90-minute period for the selenium method was requested.

The data obtained are shown in Table IV.

TABLE IV
CRUDE PROTEIN DETERMINATIONS WITH 0.075 GM. OF SELENIUM COMPARED WITH THE
STANDARD METHOD

Catalyst and time of digestion	Crude protein content	
	Mill-run	Straight-grade
	<i>P.ct.</i>	<i>P.ct.</i>
HgO —45-minute digestion	16.90	12.79
Selenium		
45-minute digestion	16.66	12.46
90-minute digestion	16.50	12.16

The results given in Table IV again confirm the evidence that has been accumulating, namely, that metallic selenium as a replacement for red mercuric oxide in the standard Kjeldahl digest formula of the A. A. C. C. inevitably leads to low results.

The findings given in the three sets of analytical data just presented are further confirmed by the collaborative study undertaken by the 1933 Methods of Analysis Committee of the A. A. C. C. (see Davis and Wise, 1933). Nine of the ten collaborators who cooperated in this study obtained lower results when selenium was used as the catalyst in place of the red mercuric oxide when determining the crude protein content of mill-run and straight-grade flour. In fact, Davis and Wise conclude from the results of their collaborative studies that "... as a Kjeldahl catalyst, selenium does not appear to be universally adaptable to general laboratory conditions as does mercury, and its use in combination with common catalysts, especially mercury is to be discouraged. The indications favor a lower result with its use. . . ."

The unsatisfactory results obtained with metallic selenium suggested the use of some of its compounds. Trials were therefore undertaken with selenious acid (SeO_2). The oxide, SeO_2 , was dissolved in warm concentrated H_2SO_4 in the equivalent of 0.15 gm. of SeO_2 to each 20 cc. of acid. Preliminary trials soon demonstrated that SeO_2 alone was not an efficient catalyst although clearing of the digest occurred at from 7 to 8 minutes. It was again found that mossy zinc could not be used

as an ebullient; granular zinc could, however, be used. Although no frothing difficulties arose, some development of noxious fumes was noticeable. Low results were the rule.

In combination with metallic copper, however, SeO_2 appeared to work very well, 0.05 gm. of Cu appearing to be sufficient. Complete clearing of the digest took place in approximately 8 minutes.

The results obtained with a digestion mixture containing 0.15 gm. of SeO_2 , 0.05 gm. Cu, 10 gms. K_2SO_4 , and 20 cc. of H_2SO_4 (Sp. gr. 1.82) are shown in Table V.

TABLE V
CRUDE PROTEIN DETERMINATIONS WITH 0.15 GM. SeO_2 , AND 0.05 GM. CU, COMPARED WITH THE STANDARD METHOD

Method and time of digestion	Crude protein content							
	Sample number							
	1	2	3	4	5	6	7	8
	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>
Standard— 30-minute digestion	9.58	10.22	11.20	12.08	12.60	14.08	14.50	15.92
Selenium oxide copper modification								
15-minute digestion	9.32	10.04	10.88	11.73	12.68	14.00	14.57	15.69
20-minute digestion	9.39	10.12	10.98	11.77	12.64	13.95	14.37	15.78
25-minute digestion	9.50	10.22	11.02	11.91	12.59	14.04	14.48	15.87

From a study of the data shown in Table V it would appear that although the protein determinations obtained at the end of the 25-minute digestion period with 0.15 gm. of SeO_2 and 0.05 gm. of Cu as the replacement catalysts approximated quite closely those obtained by the standard method, particularly with the high protein samples, this combination falls a little short of the correct results with the low protein-high carbonaceous material.

The selenious oxide content of the mixture was then increased to 0.3 gm., the copper content remaining the same, and further trials were made. The results of the determinations are given in Table VI. Four digestion periods were used—15, 20, 25, and 30 minutes.

It appears that this combination of catalysts with a 20-minute digestion period will give results comparable to those obtained with the standard method in which digestion proceeds for 30 minutes. However, reference to Table I in which is given the results for various digestion periods by the standard method will show that, with the excep-

TABLE VI
CRUDE PROTEIN DETERMINATIONS WITH 0.3 GM. SeO_2 , AND 0.05 GM. CU COMPARED
WITH THE STANDARD METHOD

Method and time of digestion	Crude protein content							
	Sample number							
	1	2	3	4	5	6	7	8
	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>
Standard— 30-minute digestion	9.58	10.22	11.20	12.08	12.60	14.08	14.50	15.92
Selenium oxide copper modification—								
15-minute digestion	9.37	10.04	11.02	11.83	12.55	13.95	14.40	15.78
20-minute digestion	9.55	10.20	11.20	12.00	12.56	14.04	14.57	15.96
25-minute digestion	9.55	10.22	11.25	12.00	12.70	14.13	14.48	15.92
30-minute digestion	9.55	10.22	11.15	11.88	12.64	14.04	14.53	15.87

tion of samples 7 and 8 (the high protein samples), the standard method with a 20-minute digestion period was just as efficient as was the modified selenium oxide-copper method. At the end of a 25-minute digestion period both methods produced results commensurate with the error of protein analysis with wheat samples, *viz.*, 0.1%.

It would thus appear then that when the cost of electrical energy for an additional five minutes (roughly 50 watts) plus the cost of 0.5 gm. of red HgO is balanced against that of 0.3 gm. of SeO_2 (at \$8.00 per pound) minus the saving of a mercury precipitant, little can be claimed for the latter as an economical substitute for red HgO in determining the protein content of wheat.

SeOCl_2 as a Kjeldahl Catalyst

The use of SeOCl_2 as a Kjeldahl catalyst in wheat protein determinations was also studied. As recommended by Rich (1932) 0.2 cc. of SeOCl_2 was added to the Kjeldahl flask by means of an eye dropper. Samples 1, 3, 6, and 8 were used as test material. Granular zinc was used as the ebullient. SeOCl_2 was the slowest of all the selenium catalysts in clearing the digest as 9 minutes were necessary. With the exception of the 30-minute digestion period with SeOCl_2 the results obtained are hardly worth reporting. This also is true of all results using SeOCl_2 in combination with copper. Results for the digestion studies with SeOCl_2 in comparison with the standard method are reported in Table VII. Very unsatisfactory results were obtained when SeOCl_2 was used in combination with copper. These results are of

TABLE VII
CRUDE PROTEIN DETERMINATIONS WITH SeOCl_2 COMPARED WITH THE STANDARD METHOD

Method and time of digestion	Crude protein content			
	Sample number			
	1	3	6	8
	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>
Standard— 30-minute digestion	9.58	11.20	14.08	15.92
SeOCl_2 modification— 20-minute digestion	8.97	10.46	13.00	15.10
30-minute digestion	9.10	10.77	13.43	15.07
$\text{SeOCl}_2 + 0.05 \text{ gm. Cu}$ modification— 20-minute digestion	8.78	10.55	13.10	15.08
30-minute digestion	8.83	10.51	13.41	15.02

course at variance with those of Rich (1932) who claims that "selenium oxychloride as a catalyst in combination with copper indicates that a considerable saving in time . . . can be expected from their use."

Nickel-Selenium as Kjeldahl Catalyst

Nickel (0.25 gm.) and metallic selenium (0.10 gm.) in combination were substituted for red HgO in the standard formula and samples 1, 3, 6, and 8 were digested for 25 and 30 minutes. The pertinent data are presented in Table VIII. Outstanding in the use of these catalysts was the rapid clearing of the digest, this being accomplished in ap-

TABLE VIII
CRUDE PROTEIN DETERMINATIONS WITH 0.25 GM. Ni , AND 0.10 GM. Se , COMPARED WITH THE STANDARD METHOD

Method and time of digestion	Crude protein content			
	Sample number			
	1	2	3	4
	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>	<i>P.ct.</i>
Standard— 30-minute digestion	9.58	11.20	14.08	15.92
Ni-Se modification— 20-minute digestion	9.20	10.98	13.87	13.53
30-minute digestion	9.47	10.94	13.95	15.62

proximately 6 to 7 minutes. The phenomena is very interesting and well merits further study. However, as can be seen, the determinations were low as compared with the standard method, and noxious fumes in large quantity prevailed during and after distillation. Further, it is impossible to use any form of zinc as an ebullient in the presence of nickel and selenium.

Other Combinations of Selenium Catalysts

Further trials were made using various combinations of selenium with Cu and HgO, but no better results were obtained than those reported. Trials were also made using Devarda's alloy. The results were entirely without value.

Discussion

Considering the fact that others have investigated selenium and its compounds as a catalyst and reported favorably, it is only fair to assume that the laboratory conditions under which their data were obtained justified their recommendation.

It may be that selenium can be used satisfactorily as such in the analysis of coal, fertilizer, milk, etc., and that selenium or its compounds can even be used in the analysis of flour and cereals under certain conditions. However, most of the data furnished by those investigators recommending the use of selenium or its compounds are expressed in terms of nitrogen content. Admittedly, the variance from the standard method is apparently small. When the nitrogen data are converted into protein percentages, the values used in wheat and flour merchandising, this error is pyramided to such an extent that the cereal laboratory becomes very cautious about its use. Furthermore, it is unsafe to reach conclusions on the basis of duplicate or even triplicate analyses. In these experiments, where replicates of eight were run, any number of instances could be singled out that compare identically with the results obtained by the standard method; but, averaging the eight replicate tests, this did not hold true. The greater the number of tests made in this experiment, it became more and more apparent that selenium tends to produce low results.

To be entirely acceptable, it seems that any substitute for mercury should not increase the degree of precision required in the Kjeldahl test, but lessen it. Only by exercising the greatest of care in the distillation of selenium digests could any reasonable results be obtained. Bumping or frothing occurred in almost every instance unless special precautions were taken. Unless these annoying features can be overcome and accurate results be obtained, it hardly seems worth while to

attempt to replace the entirely satisfactory mercuric oxide catalyst, sacrificing accuracy for the sake of saving a few minutes.

Conclusions

From the data assembled in this paper, the following conclusions can be drawn:

Successive five-gram increments (5 to 15 gms.) of K_2SO_4 when added to boiling sulphuric acid (Sp. gr. 1.82) raises the ultimate boiling point of the acid from approximately $345^\circ C.$ to $385^\circ C.$ or an approximate $3^\circ C.$ rise for each gram of K_2SO_4 added.

The addition of 0.5 gm. of HgO to a mixture of 20 cc. of H_2SO_4 (Sp. gr. 1.82) and 10 gms. of K_2SO_4 raised the boiling point of the mixture but $2^\circ C.$

During the oxidation of one gram of wheat meal the rise in temperature of the digest is more rapid than is the case with any of the salt and/or red oxide of mercury mixtures. The final temperature developed was approximately $379^\circ C.$ or $10^\circ C.$ above the temperature of the boiling reagents.

The use of 0.5 gm. of red HgO induced a more rapid rise in temperature in the standard boiling digestion mixture than did either 200 mgs. of metallic selenium or 0.2 cc. of $SeOCl_2$. This is likewise true for the selenium-copper mixture (0.3 gm. SeO_2 and 0.05 gm. Cu).

The comparative temperatures developed with 500 mgs. Se and 500 mgs. red HgO show a final higher boiling temperature for the selenium addition.

The rapid clearing of selenium digests must be explained in large part by catalytic effects as this clearing appears at much lower boiling temperatures than is characteristic of the HgO - K_2SO_4 digests which have a much higher boiling point.

What has been said of selenium must also be true, in part, for red HgO as the $2^\circ C.$ rise in temperature caused by the addition of 0.5 gm. of red HgO is not sufficient to explain the more rapid digestion phenomena when this reagent is added.

The substitution of metallic selenium, in amounts varying from 75 to 250 mgs. for the 0.5 gm. of red HgO in the Kjeldahl digestion mixture results in low values when analyzing wheat for crude protein content.

The use of a combination of 0.3 gm. SeO_2 and 0.05 gm. of copper in place of the 0.5 gm. red HgO in the formula reduces somewhat the time (15 to 20%) necessary for determinations. The difference is not significant when the extra cost of the selenious acid is taken into consideration.

The use of selenium oxychloride as a catalyst in the amounts used—0.2 cc.—has no advantage over 0.5 gm. of red HgO .

The use of a combination of 0.1 gm. of nickel and 0.1 gm. of selenium as catalysts, while inducing the most rapid digest clearing time, gave protein determinations that were too low.

There is apparently no positive relationship between rapidity of clearing of the digests and the accuracy of the protein determinations. Indeed the slowest clearing digest (the standard procedure with a 12-minute clearing) accompanied the most accurate results.

Mossy zinc cannot be used as an ebullient with selenium in any of its forms as it causes excessive frothing. Granular zinc (30 mesh), however, can be used.

Noxious fumes, presumably hydrogen-selenide, are always present when zinc in any form is used as an ebullient if by any chance the caustic used for neutralization of the diluted digest is not sufficiently concentrated to insure strong alkalinity. These fumes present a serious health hazard, especially when large numbers of tests are being carried on.

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MINUTES OF THE TWENTIETH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF CEREAL CHEMISTS

Royal York Hotel, Toronto, Canada

June 4-7, 1934

M. D. Mize, *Secretary-Treasurer*

Monday, June 4

Meeting called to order at 10:00 a.m. by President R. C. Sherwood.

Invocation by J. Avery Dunn was followed by the singing of "God Save the King" and "America."

W. G. McLeod, Chairman of the Toronto Section of the Canadian Chemical Association, delivered a message of welcome and expressed the desire for further cooperation between the two Associations.

Dr. E. F. Burton, Professor of Physics of the University of Toronto, delivered the address: "The Peculiar Action of Thin Films of Water."

In the absence of His Worship, the Mayor of Toronto, W. J. Stewart, Controller Robins delivered a message of welcome to the City of Toronto.

President Sherwood delivered the address given on pages 446 to 450 of this issue of CEREAL CHEMISTRY.

A message of greeting from Henry Stude, President of the American Bakers Association, was read by C. B. Morison.

Messages of greeting were also received and read from Leslie R. Olsen, Geo. R. Stadler, Chairman of the Nebraska Section, C. B. Kress, H. W. Putnam, Chairman of the Publicity Committee, and The Management of the Convention Bureau of the Canadian National Railway.

R. W. Mitchell read words in reverence to the memory of Harry E. Weaver and C. M. Murphy, while the members present stood in reverent silence in their memory.

A. E. Cliffe, Chairman of the Local Arrangements Committee, was presented before the meeting. He welcomed those present and made some announcements relative to special arrangements in connection with the convention program.

M. J. Blish, Chairman of the Program Committee, was also presented before the meeting.

The following committees were appointed by President Sherwood:

Resolutions Committee: Charles H. MacIntosh, Chairman, M. A. Gray, N. L. Gregory.

Nominating Committee: L. D. Whiting, Chairman, R. W. Mitchell, A. A. Schaal.

President Sherwood presented A. E. Cliffe with Charter No. 11 which had been granted by the Executive Committee to the Toronto Local Section.

Meeting adjourned at 12:00 noon by President Sherwood.

Meeting called to order at 1:30 p.m. by President Sherwood and placed in charge of F. L. Dunlap, Chairman for the afternoon.

Report of Committee on Methods of Analysis, C. G. Harrel, Chairman, who gave a general report and summary of the work undertaken.

Sub-report—"Correlation of Diastatic Activity and Gassing Power in Commercial Flours," by C. F. Davis, read by C. H. MacIntosh.

Sub-report—"Diastatic Activity in Suspensions and Doughs," by R. M. Sandstedt.

Sub-report—"Viscosity Tests," by E. G. Bayfield.

Sub-report—"Study of the 130° Oven Moisture Method," by J. H. Lanning, read by C. G. Harrel.

Sub-report—"Revision of the Methods of Analysis," by C. E. Mangels.

Paper—"The Blish-Sandstedt Method for Diastatic Activity Applied to Whole Wheat and Some Other Cereal Grains," by S. R. Snider, H. B. Dixon, and D. A. Coleman, read by D. A. Coleman.

Paper—"A Comparative Study of the 'Ferricyanide' and 'Quisumbing and Thomas' Procedures for Maltose Determinations in Diastatic Activity Measurements," by W. F. Geddes and W. J. Eva, read by W. F. Geddes.

Paper—"A Comparative Study of Methods for Determining Moisture in Cereal Grains," by W. H. Cook, J. W. Hopkins, and W. F. Geddes.

Paper—"Some Observations on the Use of Selenium and Its Compounds as Catalyst in the Determination of Nitrogen in Wheat and Flour by the Kjeldahl Method," by S. R. Snider and D. A. Coleman, read by D. A. Coleman.

The Northwest Section presented a number of slides and messages depicting current events.

Meeting adjourned at 4:30 p.m. and the entire convention met at Centre Island Park for the Annual Picnic.

The Fleischmann Company Film "Enzymes in Dough" was presented at 8:30 p.m. by C. N. Frey.

Tuesday, June 5

At 7:30 a.m., a breakfast was held for the meeting of the officers of the Association with the Chairmen of the Local Sections.

Meeting called to order at 9:00 a.m., by President Sherwood, and C. B. Morrison was placed in charge as Chairman of the morning program.

Paper—"Enzymes of Flour in Relation to Yeast Fermentation," by Q. Landis and C. N. Frey, read by Q. Landis.

Paper—"Factors Affecting the Diastatic Activity of Wheat Flour," by M. C. Markley and C. H. Bailey, read by M. C. Markley.

Paper—"The Relation of Diastatic Activity and Gassing Power to Bread Quality," by E. B. Working, read by M. J. Blish.

Report of Committee on Standardization of Laboratory Baking, W. F. Geddes, Chairman, who gave a general report of the work undertaken during the year.

Sub-report—"A Survey of Test Baking Procedures Employed in America," by T. R. Aitken.

Sub-report—"Control of Yeast Variability in Gassing Power Tests," by R. M. Sandstedt and M. J. Blish, read by M. J. Blish.

Sub-report—"Notes on the Interpretation of the A. A. C. C. Baking Test," by R. T. Bohn.

Sub-report—"Mixing Time Experiments with Flours Milled from Different Classes of Wheats," by R. Weaver and C. C. Fifield, read by C. C. Fifield.

Sub-report—"Diastatic Supplements for the A. A. C. C. Baking Test," by Q. Landis.

Sub-report—"Further Tests with Motor Driven Dough Sheeter Made with the Collaboration of The Fleischmann Laboratories, Borden Laboratories, and the Wallace & Tiernan Company," by C. N. Frey, read by J. Freilich.

Sub-report—"Observations on Grain and Texture," by G. Moen, read by F. A. Collatz.

Sub-report—"Effects of Variation in Baking Formula on Gas Production and Loaf Volume," by R. K. Larmour and S. F. Brockington, read by R. K. Larmour.

Sub-report—"The Effect of Varying Fermentation Time on Gas Production and Loaf Volume," by R. K. Larmour and S. F. Brockington, read by R. K. Larmour.

Sub-report—"The Relation Between Protein Content and Flour Strength as Determined by Different Baking Procedures," by T. R. Aitken and W. F. Geddes, read by T. R. Aitken.

Sub-report—"The Determinations of Water Absorbing Capacity of Flour by Means of the Super Centrifuge," by E. B. Working, read by W. F. Geddes.

Sub-report—"Flour Strength as Determined by Different Methods," by D. W. Kent-Jones and W. F. Geddes, read by W. F. Geddes.

Sub-report—"The Unsuitability of the Bromate Baking Test in Determining the Strength of Experimentally Milled Flours of Low Diastatic Activity," by W. F. Geddes and A. G. McCalla, read by W. F. Geddes.

Paper—"Variability in Experimental Baking Using Hand and Machine Manipulation," by J. G. Malloch and J. W. Hopkins, read by J. G. Malloch.

Paper—"Temperature Control in the Baking Test with Revolving Shelves in Proofing Cabinet," by W. O. Whitcomb, read by M. J. Blish.

Samples of bread were distributed for a bread judging contest by the members of the New York Section.

Meeting adjourned at 12:00 noon.

At 8:00 p.m., a joint session with the Canadian Chemical Association was held at the Main Lecture Theater, Physics Building, University of Toronto: Lecture by Dr. John Satterly, "Liquid Air."

Wednesday, June 6

Meeting called to order by President Sherwood and placed in charge of Mary M. Brooke, Chairman for the morning.

Report of Committee on Testing Pie Flours, by C. B. Kress, Chairman, read by R. C. Sherwood. R. C. Sherwood moved that this report be accepted. Seconded, carried.

Report of the Committee on Testing Biscuit and Cracker Flours, by R. M. Bohn, Chairman. R. M. Bohn moved that this report be accepted. Seconded, carried.

Report of the Committee on Testing Rye Flours, by L. H. Bailey, Chairman. L. H. Bailey moved that this report be accepted. Seconded, carried.

Report of the Committee on Testing Self-Rising Flours, by H. G. Walter, Chairman.

Sub-report—"Study of Difference in Mixer Types as Applied to Biscuit Baking Test," by R. A. Barackman.

Sub-report—"The Judging of Texture of Baked Biscuits," by H. V. Moss.

Sub-report—"Flavor Scoring," by R. A. Barackman.

H. G. Walter read all sub-reports and moved that the entire report of the committee be accepted. Seconded, carried.

Report of the Committee on Cake Baking Tests, by G. L. Alexander, Chairman, who gave a general report of the work undertaken.

Sub-Report—"Further Refinement of Cake Mixing and Baking Procedure, with Special Attention to Construction of Mixers and Ovens," by W. R. Green, read by P. Rumold.

Sub-report—"A Study of Leavening Used in the Official Cake Baking Test, with Suggestions Regarding Its Standardization," by W. E. Stokes.

Sub-report—"A Study of Physical and Chemical Properties of Dried Skim Milk and Its Standardization for Use in the Official Cake Baking Test," by R. T. Bohn.

Sub-report—"A Study of Some Physical and Chemical Properties of Dried Egg Albumin, with the View of Standardizing This Substance for the Official Cake Baking Test," by C. A. Glabau.

G. L. Alexander read the recommendations of his committee and moved that they be accepted. Seconded, carried.

Meeting was turned back to R. C. Sherwood for the conduction of the business session.

C. H. Bailey moved the Minutes of the 1933 convention by M. D. Mize, Secretary-Treasurer, be approved as printed in CEREAL CHEMISTRY, Vol. 10, No. 4, pages 372-381. Seconded, by J. A. Dunn; carried.

M. A. Gray moved that the Annual Financial Report of the Secretary-Treasurer for the year 1933 be approved as printed in CEREAL CHEMISTRY, Vol. 11, No. 2, page 236. Seconded, by C. E. Mangels; carried.

P. Rumold moved that the Auditing Committee Report be approved as printed in CEREAL CHEMISTRY, Vol. 10, No. 2, page 238. Seconded, by Pearl Brown; carried.

Report of the Special Auditing Committee

J. H. LeClerc and L. H. Bailey

The Special Auditing Committee has examined the books of the Managing Editor for the calendar Year 1933 and has found the same to be correct.

It is recommended that hereafter the accounts of the Managing Editor should be examined as soon as practicable after January 1st each year, and that the report of the Auditing Committee be published in the March number of CEREAL CHEMISTRY, along with the Annual Report of the Secretary-Treasurer.

L. H. Bailey moved that this report be accepted. Seconded, by W. Platt; carried.

Report of the Editor-in-Chief

D. A. Coleman

During the past year many manuscripts passed through your editor's hands. The task of editing this material has not been an easy one because of the condition in which some of them were received. I, therefore, want to appeal to you all at this time to be more careful in the preparation of your manuscripts. On several occasions during the year, the timely printing of the journal has been delayed for lack of copy. It will be appreciated most heartily if those of you who contemplate publishing during the coming year will get your manuscripts into the editor's hands at as early a date as possible, so that the editorial staff can have themselves in the position of being one number ahead of the printer.

C. E. Mangels moved that the report of the Editor-in-Chief be accepted. Seconded, by M. M. Brooke; carried.

The report of the Managing Editor, C. C. Fifield, is incorporated in the Annual Report of the Secretary-Treasurer, Volume 11, No. 2, page 236.

Report of the Executive Committee

Mary M. Brooke, Chairman

Dr. Sherwood, in his report at the Nineteenth Annual Convention, stated that the functions of the committee during his term of office as vice-president and chairman had been largely financial, and dealt with the disposition of the funds of the Association during the financial distress.

Due to the excellent way in which Mr. Mize and the executive committee of last year handled this situation, little difficulty and no weighty decisions were necessary this year. Only one major move was made, and that was to remove the money from the Omaha Building and Loan and buy United States Treasury Certificates. All other sums of money have been placed in government-insured bank savings in order to be liquid for investment at opportune times.

However, the activities of the executive committee have been in the direction of conservatively and constructively spending the money of the Association rather than saving it throughout the year, as we shall be informed as we go through the report.

One of the first duties of the executive committee was to choose the 1934 meeting place. This year a new departure was innovated and a return card voting system was inaugurated. The majority of the votes of the membership was in favor of Toronto. The executive committee, seeing no reason for not following popular decision, voted to have the Twentieth Annual Meeting at Toronto.

Next, the committee unanimously decided to appropriate the sum of \$150.00 to have the history of the Association printed and mailed to the members of the Association. The history committee has worked hard and long to prepare this history and we felt that the time was justifiably right for the publication.

The committee decided that it would be proper to have one of the auditing committee audit the books of the managing editor of CEREAL CHEMISTRY to tie in with the auditing of the secretary-treasurer's report. This was done this year by the appointment of a special committee by Dr. Sherwood. However, later discussion by the executive committee provided that one member of the auditing committee should be appointed who was in a geographical location to audit these books and meet with the other two members of the auditing committee.

A charter for Local Section No. 11, the Toronto section, was signed with a great deal of pleasure and, as you all know, delivered to Dr. Cliffe, their chairman, on Monday morning. We are indeed glad to welcome this new member to our family of local sections. We feel that it is going to be a successful and a fruitful addition to the national association.

The publication of a decennial index to CEREAL CHEMISTRY was a problem which involved much time, thought and effort for the last six months. Finally Dr. Sherwood and the chairman decided that the proper procedure would be to get together the executive committee, the editors of CEREAL CHEMISTRY, and the officers of the Association, and make a decision at that time. This was done on last Sunday afternoon, June 2d, with the following decision made:

That the Decennial Index should be published; that the publication should be given to members and subscribers gratis; that the expense should be equally divided between the Association and CEREAL CHEMISTRY; that the cost should be taken from the respective reserve funds of the two and that it then be charged off the regular income of the two activities for a period of four years and returned to the reserve fund; and that an expenditure of \$650.00 maximum be authorized for this purpose.

The committee authorized the publicity committee expenses for printing and mailing the memo cards. We felt that these cards play a definite rôle in the activities of the Association.

The committee approved the idea and authorized the expenditure for \$250.00 for taking notes, printing and mailing the proceedings of the Twentieth Annual Meeting.

The committee approved a registration fee of \$4.00 for the Twentieth Annual Meeting.

As to recommendations:

The executive committee recommends to a future executive committee that beginning in 1938, CEREAL CHEMISTRY and the Association set aside a fund over the following six-years period to pay for a second decennial index.

The executive committee of next year should consider and recommend minor necessary revisions of the constitution for action of the Association at its Twenty-First Meeting.

The executive committee has considered publication of the Book of Methods. Further comments of the membership are requested before further action of the committee is taken.

The chairman wishes to express to the members of the committee and to the secretary-treasurer her appreciation for the splendid cooperation and extreme good will throughout the year.

W. Platt moved that the report of the Executive Committee be accepted. Seconded, by C. H. MacIntosh; carried.

Report of the Membership Committee

L. E. Jackson, Chairman

This committee was originally composed of all 1933 sectional chairmen. Later, Mr. Clarence Oppen, Chairman of the Cincinnati Division of the Central States Section, and Dr. A. E. Cliffe, of the newly formed Toronto Section, were invited to co-operate.

As Chairman of this committee, I consider it a privilege to offer the following report:

New members signed and accepted	51
Old members reinstated	7
Total	58
Members resigned and deceased	12
Members dropped for failure to pay dues	19
Net gain	27

I believe it is only fair that both the Central States Section and the Toronto Section, who produced ten and thirteen members, respectively, should receive mention. As far as individual effort is concerned, Dr. Cliffe was outstanding, having personally signed up ten new members.

This committee has the following suggestions to offer for consideration:

1. In view of the fact that sectional chairmen are best qualified for work of this type, it is suggested that all future membership committees be composed of the various sectional chairmen.

2. That next year's committee be furnished with a complete list of all former members who have dropped out of the Association and an attempt be made to personally interview each one of these men and determine whether or not they are still interested in the activities and benefits of the Association.

3. That some arrangements be made so that the membership committee can co-operate with the secretary of the Association in contacting members who are delinquent in their dues.

4. That some consideration be given to the advisability of eliminating the three-dollar initiation fee and simply charging seven dollars for all newly signed members.

C. E. Mangels moved that the report of the Membership Committee be accepted and that the committee be complemented on the excellent work done during the year. Seconded, by P. Logue; carried.

Report of the Employment Committee

C. B. Morison, Chairman

Letters, correspondence from June 5, 1933 to June 4, 1934	104
Positions filled	4
Employers requesting assistance	6
Names registered from June 5, 1933 to June 4, 1934	19
Previous names registered	206
Total	225

J. A. Dunn moved that the report of the Employment Committee be accepted. Seconded, by C. N. Hanson; carried.

Report of the Publicity Committee

H. W. Putnam, Chairman

The Publicity Committee, consisting of Messrs. Frye, Gray, Haley, Ingels, Marx, and Putnam, offers the following report of its efforts to keep the constructive work and activities of the Association before the public during the year.

Every important meeting and activity has been covered in the more than sixty reports forwarded to a list of twenty-eight scientific journals and trade publications. Publishers have given generous space to reports of Association activities. In addition, for articles of sufficient interest and importance, an effort was made to reach the consuming public through certain newspapers.

Advance copies of news stories, prepared from abstracts of papers on the Toronto program have been mailed publishers and interested newspapers. Also daily reports of news events will be mailed during the meeting.

To more quickly disseminate some items and to supplement the News Letter, copies of releases were frequently sent Section Chairmen and National Officers. Coordination of the publicity activities of various Sections and Committees was sought by providing each with a list of publishers so that timely items could be sent directly. Section chairmen co-operated by furnishing news items and by exchanging with fellow chairmen notices and bulletins sent their respective groups. Some seventeen communications were prepared by the committee in carrying out these news clearing-house activities.

For a third successive year, a memo-card, containing the names and addresses of the officers, the section chairmen, and the past presidents, together with data on Section Meetings, and an announcement of the Toronto Meeting date was mailed to all members.

Mr. H. T. Corson, executive manager of the National Food Bureau (Chicago, Ill.), courteously arranged to send Food Facts to all members of the Association.

Mr. E. S. Stateler of Food Industries (New York) and Dr. Harrison E. Howe of Industrial & Engineering Chemistry (Washington, D. C.) were especially helpful in offering suggestions for extending and improving the publicity work.

The committee is aware of the limited nature of the trade press audience with its narrow appeal to the public. It is felt, however, that service has been rendered by the dissemination of information, that non-members may have been stimulated to consider membership, and that the Association has earned more respect within the industry.

The American Chemical Society News Service has shown that Chemistry can be an appropriate theme in every department of a newspaper. Its activities have identified chemists with the industries, public health, fundamental research of all kinds, and with the larger affairs of life as well as with laboratories and test tubes.

Its releases have challenged the interest of serious-minded though technically untrained readers. Real explanations rather than more popularization of chemistry are helping Americans to be discriminating science readers, and are largely helping chemists to more directly and more effectively participate in public thought and action.

Perhaps the American Association of Cereal Chemists bears no parallel to the American Chemical Society. However, the success of the A. C. S. News Service is such as to suggest that some further investigation be made by succeeding publicity committees on methods of reaching the public. Certainly there is ample room for every member of the Association to speak for himself and his profession by writing for local papers and by speaking before various groups.

M. A. Gray read the report of the Publicity Committee and moved that it be accepted. Seconded, by E. S. Stateler; carried.

Report of the History Committee

R. Wallace Mitchell, Chairman

The committee has continued the work that was reported upon at the last general assembly. The History is not complete to the present date but has been finished up to and including the term of President Gray.

The manuscript was turned over to President Sherwood last month and it is the understanding of the committee that certain plans have been made to have the manuscript prepared in permanent form for general distribution.

The committee wishes to thank the membership for the patience which it has shown in waiting for this work to be developed and we wish to again thank those who have co-operated so generously when called upon for assistance. We believe that the record should be continued and that an effort should be made to get the history complete to within two years of the present time and then maintained as a permanent institution.

R. W. Mitchell moved that this report be accepted. Seconded, by P. E. Minton; carried.

Report of the Committee on Resolutions

C. H. MacIntosh, Chairman

Whereas, The American Association of Cereal Chemists has experienced another successful annual meeting, and

Whereas, this success has been very largely due to the splendid service rendered by the officers and committees of the Association,

Therefore, be it resolved that the appreciation of the Association be expressed to the officers serving during the past year: President, Dr. R. C. Sherwood; Vice-President, Mrs. Mary Minton Brooke; Secretary-Treasurer, M. D. Mize; and to the Program Committee, Dr. M. J. Blish, Chairman; the Local Arrangements Committee, Dr. A. E. Cliffe, Chairman; the Ladies Entertainment Committee, Mrs. A. E. Cliffe, Chairman; and to all other committees so successfully contributing to the year's work.

Be it further resolved, that we express our appreciation to Dr. D. A. Coleman, Editor-in-Chief, and his associates on the business and editorial staff of CEREAL CHEMISTRY for their splendid work during the year just passed.

Be it further resolved, that we extend our thanks to Controller Robins for the fine welcome extended the Association on behalf of the City of Toronto.

Be it further resolved, that we express our thanks to Mr. W. G. McLeod, Chairman of the Toronto Section, for his welcoming address on behalf of the Canadian Chemical Association.

Be it further resolved, that we express our appreciation to Dr. E. F. Burton, and his assistant Mr. Pitt, of the Department of Physics of the University of Toronto, for the splendid presentation of the subject selected.

Be it further resolved, that we express our appreciation to Dr. John Satterly for his most entertaining and instructive lecture on "Liquid Air."

Be it further resolved, that we express our appreciation to the following contributors of the golf trophies: General Mills, Wallace & Tiernan Company, Inc., Wesson Oil and Snowdrift Sales Company, Durkee's Famous Foods, Inc., Victor Chemical Works, Provident Chemical Works, Central Scientific Company.

Be it further resolved, that we extend our thanks to the Victor Chemical Works, Provident Chemical Works, Maple Leaf Milling Company, Standard Brands, T. Eaton Company, Robert Simpson Company and the City of Toronto for their assistance to the Ladies Committee.

Be it further resolved, that we extend our thanks to the General Board of Religious Education, Toronto, for their courtesy in furnishing the projection lantern for this meeting.

Be it further resolved, that we express our appreciation for the splendid cooperation of Mr. Mann, Convention Manager of the Royal York Hotel, and the Toronto Convention and Tourists Association, in assisting the Local Arrangements Committee.

Whereas, during the year, two of our members have passed on to their reward,

Be it resolved, that we express our deep regret at the passing of Harry E. Weaver, who contributed so much to the formation of this Association, served as its first President and was a constant source of inspiration by his continued loyalty and wise counsel.

Be it further resolved, that we express our deep regret at the tragic passing of another active member, Mr. C. M. Murphy.

Be it further resolved, that the Secretary be instructed to convey to their families the deep sympathies of the Association.

C. H. MacIntosh moved that this report be accepted. Seconded, by R. A. Barackman; carried.

C. E. Mangels who was appointed by President Sherwood last year to completely revise the present edition of the book "Methods of Analysis of Cereals and Cereal Products," reported that the manuscript for the new edition is practically completed. In order to determine the advisability of printing a new edition of this book, President Sherwood called for a rising vote of all those present who were in favor of having the new edition printed at this time. A large majority of those present voted "yes." President Sherwood then called for all of those present who would buy a copy of the new edition to please stand and a count of those standing showed that practically all present desired a copy. President Sherwood stated that the information obtained from these two ballots would be further considered by the Executive Committee and arrangements would be made by them for the printing of the book during the coming year.

The recommendations of the Committee on Standardization of Laboratory Baking, W. F. Geddes, Chairman, were further considered at this time. G. F. Garnatz moved that graniteware oatmeal bowls, inside dimensions, top diameter 14.5 cm., bottom diameter 5 cm., and depth 6.5 cm., replace the present sized bowls for use as fermentation bowls. Seconded, by E. A. Vaupel; carried.

C. H. MacIntosh moved that the baking pans hereafter be constructed of 2XX tins and that both the tall and low form pans may be employed. The dimensions of the low form pans are: Length—top 11.5 cm., bottom 9.5 cm.; Width—top 7.0 cm., bottom 5.5 cm.; Depth 5.0 cm. Seconded, by A. G. O. Whiteside; carried.

J. A. Dunn moved that variable absorption replace fixed absorption and be specified in the basic baking formula.

P. E. Minton moved that for mixing procedure the Hobart-Swanson Mixer with a mixing time of one minute specified be adopted as the official procedure. When the Hobart-Swanson Mixer is not available, hand mixing and mixing with the two-hook Hobart will be allowed. Seconded, by E. E. Smith. P. E. Minton amended the above motion to the effect that the adoption of the Hobart-Swanson Mixer would be contingent on the manufacturer's ability to keep a stock of the mixers on hand at all times. Seconded and after some discussion, the amendment was lost. P. E. Minton with the consent of the second then withdrew his original motion. G. F. Garnatz moved that the mixing procedure recommendation be referred back to the Committee for further study and consideration with the special attention of including the creaming paddle used on the Hobart Mixer. Seconded, by Pearl Brown. R. W. Mitchell amended the motion to the effect that the Committee be required to make a report by Thursday morning. Seconded, by C. C. Fifield; carried. The motion as amended was then voted upon and carried.

(In order to improve the continuity of these Minutes, liberty is taken of inserting here the report which was made by the Baking Committee on Thursday.)

W. F. Geddes moved that in the mixing procedure, the Hobart-Swanson Mixer with a mixing time of one minute specified be adopted as official. Where

the official mixer is not available, any method of mixing may be employed which will thoroughly incorporate the ingredients and produce a smooth dough with a minimum of gluten development. For this purpose the Hobart with two-hooks, the Hobart with the cake paddle or hand mixing are suggested. Seconded, by G. F. Garnatz; carried.

C. E. Mangels moved that hereafter doughs be moulded on cotton or canvas belting rather than on a moulding board. Seconded, by M. J. Blish; carried.

C. O. Oppen extended an invitation to the Association to hold its 1935 convention in Cincinnati. G. F. Garnatz corroborated this invitation. Invitations from Washington, D. C., and Montreal were also presented and read. H. D. Liggitt again presented his standing invitation to hold our annual convention in Denver whenever desirable.

A message of greeting and best wishes with an invitation to meet in Texas was read from G. E. Findley, Chairman Lone Star Section. W. G. Epstein, Chairman of the Midwest Section, sent a message of greeting and best wishes which was read at this time.

The following cablegram was received from C. W. Brabender, Duisburg, Germany: "Looking over marvellous program and interesting paper topics I regret deeply that I cannot be with you. International Wheat Conference at Budapest prevented my coming. Greetings to all friends and success to convention."

The following telegram from Henry W. Wallace, Secretary of Agriculture, was received and read: "Please accept my best wishes for a successful annual meeting of the American Association of Cereal Chemists. Scientific work of the type carried on by your organization is valuable both to the cereal industry and to this Department."

The following telegram from R. B. Bennett, Prime Minister of Canada, was received and read: "Please express my very good wishes to American Association of Cereal Chemists. Your Association is further evidence of the friendship and cooperation existing between the nations of this continent. I sincerely hope your annual meeting in Toronto will be a success in every way."

The following telegram from R. Weir, Minister of Agriculture of Canada, was received and read: "The Government of Canada and especially our Department of Agriculture deeply appreciate the honor done us by your Association in holding its annual convention on Canadian soil. We in Canada always value the opportunity of establishing new contacts with our great southern neighbors whose army of workers in the important field of cereal chemistry has contributed so substantially to our progress as well as to your own. We wish your convention every possible success and trust you may carry away many happy recollections."

A letter from Stephen Early, Assistant Secretary to President Roosevelt, was received and read: "The President was interested to learn that the American Association of Cereal Chemists will hold its annual meeting at Toronto, Canada, June fourth to eighth. He asks me to extend, through you, to all in attendance at this meeting his sincere personal greetings and to wish you every success in the consideration of the problems confronting your organization."

"Were it not for the tremendous pressure of work upon the President, he would send this message personally. However, I am sure you will understand the situation which prevents him from doing many things he would like to do."

Election of officers:

President—Mary M. Brooke
Vice-President—Washington Platt
Secretary-Treasurer—M. D. Mize
Editor-in-Chief Cereal Chemistry—D. A. Coleman
Managing Editor Cereal Chemistry—C. C. Fifield

J. A. Dunn offered the recommendation that the Executive Committee considered the advisability of conducting two or more concurrent sessions during our future meetings.

Mrs. Mary M. Brooke, with appropriate remarks, made a motion that \$100.00 be taken from the Treasury and given to M. D. Mize as an honorarium for his very efficient services during the past year. M. A. Gray seconded the motion and the motion was carried unanimously with a rising vote from the floor in thanks to Mr. Mize for his services.

Meeting adjourned at 12:15 p.m.

Meeting called to order at 2:00 p.m., by President Sherwood and placed in charge of C. H. Bailey, Chairman for the afternoon.

Address—"A Fourth Constituent of Wildier's Bios," by Dr. W. Lash Miller, Head of the Department of Chemistry, University of Toronto.

Paper—"The Activities of the Dominion Grain Research Laboratory," by W. F. Geddes.

Paper—"The Amylases Occurring in Normal and Germinated Wheat Flour," by J. S. Andrews and C. H. Bailey, read by J. S. Andrews.

Paper—"Some Factors Influencing Soft Wheat Flour Quality," by L. J. Bohn.

Paper—"Index of Proteolytic Activity by the Use of the Farinograph," by Q. Landis.

Paper—"The Composition and Characteristics of Soybean Flour and Bread," by L. H. Bailey, Ruth G. Capen, and J. A. LeClerc, read by L. H. Bailey.

Paper—"Protein Strength and Viscosity," by E. G. Bayfield, read by W. E. Brownlee.

The Central States Section presented Professor Heissluft, I. W. W., H. A., C. W. A., P. G. A., etc., in a lecture on "Some Heretofore Unheard of Developments with the Cosmic Ray, and Their Significance in the Field of Cereal Chemistry."

Meeting adjourned at 5:00 p.m.

Thursday, June 7

Meeting was called to order by President Sherwood at 9:00 a.m., and placed in charge of Washington Platt, Chairman of the morning session.

Report of the Committee on Definitions of Technical Terms

Washington Platt, Chairman

"The less we know of a thing the more need there is for defining it." This dictum of Tyndall¹ expresses our attitude towards the present definitions.

¹"Fragments of Science." Quotation kindly supplied by Dr. E. E. Werner who had previously expressed the same sentiment.

These definitions are the outgrowth of definitions proposed by Landis and Frey, *Cereal Chem.* **10** (1933), 332-346. The discussions and charts in this paper will give the background for the present definitions.

The paper referred to divided the subjects defined into "Definitions Related to Fermentation," and "Definitions Related to Colloidal Properties." The definitions related specifically to fermentation have already been covered in the recommendations of the Committee at the 1933 Convention. See *Cereal Chemistry*, **10** (1933), 463-464. The present recommendations refer to definitions related specifically to colloidal properties.

At the request of the Committee, Local Sections of the A. A. C. C. and individual members have sent in many helpful comments. All of these have been carefully considered by the Committee which has profited greatly by this assistance.

The Committee feels that the greatest benefit will result at the present time from a study and full discussion of the definitions given below. These are therefore submitted at the present time with a recommendation for further study. It is expected that recommendations for the provisional approval of one or more of these definitions, especially the first two or three, will be made at next year's meeting.

The Definitions

The concept of a standard acceptable loaf is implied in the following definitions. Such an ideal loaf possesses an arbitrary combination of volume and textural characteristics. It is obvious that several standards may be necessary. For the present those indicated by Blish in *CEREAL CHEMISTRY* will be considered. Eventually other standards may become available.

In all the following definitions the amount of flour to be used is to be the equivalent of the weight specified at a definite and constant moisture content. (Either 13.5% or 15.0%.)

Response. The reaction of a dough to a known stimulus, substance or condition. Response may be positive (difference plus), neutral (difference zero), or negative (difference minus). When response is used unqualified, it is understood to mean the difference in loaf volume, and in this case is expressed as cc. per 100 gms. of flour unless otherwise noted.

Other responses may be specified, such as response in terms of texture, etc. In such cases, changes which are usually considered favorable are called positive unless otherwise stated.

Tolerance. The amount of any single stimulus, substance or condition which will produce neutral response in a dough system, this amount being measured from the point at which a loaf of standard characteristics first appears to the point at which these characteristics become substandard. It represents the range over which positive and/or neutral response is obtained. It is evident that in each case the "standard characteristics" must be clearly expressed or implied by the experimenter.

Note. It is to be noted that tolerance is a function of dough time.

Strength. Three different but related concepts are presented for consideration:

1. Loaf volume at maximum response, that is, loaf volume under optimum conditions.

2. Loaf volume at zero textural response. This is determined under conditions such that the texture is just standard, as defined by the standard acceptable loaf.

3. A composite of either of these two concepts together with tolerance. This depends upon the ability of a flour to produce a large loaf with a satisfactory grain and texture over a considerable range of conditions.

Note. In this definition strength would be measured not by the *height* of the loaf volume/variable condition curve, but rather as the *area* under such a curve.

Stability. Two entirely different concepts are presented for consideration:

1. The English concept. The ability of a dough to withstand slackening upon fermentation and baking. The most direct method of measuring this would probably be as the ratio of height to diameter of a round dough baked on the hearth. It would thus become a function of dough time and many other conditions.

2. The modified American concept. The extreme range of dough time over which any positive response may be obtained.

Note. This implies methods of measurement and represents the ability of the flour to make a standard acceptable loaf at the end of the specified range of dough time, the tolerance then being zero (see Chart, Fig. 3, in Landis and Frey's paper). The flour will then have the ability to make a standard loaf (or better) at any smaller value of the dough time.

This report was read by Washington Platt who also conducted the general discussion which ensued.

Report of Committee for Definition of Moisture Bases for Laboratory Reports

R. K. Durham, Chairman

To refresh your memory, the motion creating this committee will be repeated:

"That a special committee be appointed to consult and cooperate with the Millers' National Federation and others, in establishing moisture basis for reporting chemical constituents of wheat, flour and feeds."

This committee can, therefore, progress no faster than the organization with which it is cooperating. During the past year codes, freight rates, processing taxes, etc., have taken precedence over moisture bases and furthermore a situation that at the time of our annual meeting two years ago seemed quite importunate, has developed into an orderly deliberation that is keeping pace with associated events.

For example, the Control Division of the Kansas State Board of Agriculture is considering the question of fixing a moisture basis on which to calculate all items of the feeding stuff guaranty. An investigation is being carried on in that state to determine the average moisture content of wheat millfeeds when packed. The question will probably come to a decision within the next few months.

The calculation of wheat protein to a fixed moisture basis is also dependent upon a series of interrelated events. United States Department of Agriculture,

Miscellaneous Publication No. 173, issued September, 1933, entitled "Proposed Revised Federal Grain Standards," proposes to certify moisture content on all wheat graded except that for export. The Secretary of Agriculture has announced the adoption, effective July 2, of the new grain standards but it has not yet officially stated whether moisture content will appear on all certificates of domestic grading. In the event that moisture content does appear on the certificate it may be that millers will be content to accept such action as a compromise in lieu of their demand for protein calculated to some fixed moisture basis.

During the past year it was brought to the attention of this committee that air-oven methods for determination of moisture in feeds as outlined by the A. O. A. C. and the A. A. C. C. differ. The A. O. A. C. method specifies 2 hours at 135° C., whereas the A. A. C. C. method calls for only 1 hour drying at 130° C. This matter was passed on to the Methods Committee for disposition.

There is another angle to the moisture problem that must eventually be discussed and agreed upon. Both A. O. A. C. and A. A. C. C. methods specify that feed samples be ground to pass the 1 mm. sieve, before making moisture and other determinations. Obviously, for conversion purposes we should know the moisture content of the finely ground material upon which subsequent analysis is made. We should, however, also make provision for determining moisture in the original unground feed. The need for original moisture content will become more apparent, if as Kansas proposes, the weight of feed in package, as well as chemical constituents, be calculated to a fixed moisture basis.

Inasmuch as the foregoing co-pending deliberations will probably reach a decision within the next year, this committee feels that it would be unwise for the A. A. C. C. to recommend the basis or bases at this time. It is suggested that a special committee be again appointed to cooperate with various interested trade organizations and governmental agencies with a view toward the adoption of an acceptable basis for the conversion of the chemical constituents of wheat, flour and feed.

In the behalf of the Midwest Section, C. B. Morison presented the following paper: "Building for the Future."

The meeting then adjourned to reconvene at 11:00 a.m., in the joint session with the Association of Operative Millers and Toronto Bakery Engineers, with L. D. Whiting presiding as Chairman.

F. L. Talmage, President of the Association of Operative Millers, presented greetings in behalf of the Millers and delivered a talk on the "Relations between Civilization and Milling."

E. M. Joy, President of the American Society of Bakery Engineers, being absent, Victor E. Marx presented greetings in behalf of the Bakery Engineers and expressed the view of the American Society of Bakery Engineers on the relationship that should exist between the miller, chemist, and baker.

R. C. Sherwood, President of the American Association of Cereal Chemists, presented greetings in behalf of his Association and presented his view of the position of the chemist with the miller and the baker.

Paper—"The Baker Wants More Knowledge," by E. H. Bredin, President, Canadian Society of Bakery Engineers.

Paper—"The Miller and the Chemist," by W. H. McCarthy, McCarthy Milling Company.

Paper—"Power from the Prairies," by C. H. Bailey.

Meeting adjourned at 12:00 noon.

Meeting called to order 1:30 p.m., by C. N. Frey, Chairman of the afternoon.

Paper—"Varietal and Regional Variation in Common Wheat Starches," by C. E. Mangels.

W. F. Geddes presented the motion on mixing procedure which is recorded in the Minutes for Wednesday morning.

The newly elected officers were officially installed for the ensuing year.

President Mary M. Brooke appointed the following standing committees for the year:

Executive Committee

Washington Platt, Chairman
Mary M. Brooke
L. D. Whiting

H. D. Liggitt
R. C. Sherwood

Membership Committee

A. E. Cliffe, Chairman

(Chairmen of the other ten Local Sections constitute the members of this Committee.)

Committee on Methods of Analysis

Betty Sullivan, Chairman
C. F. Davis
E. G. Bayfield
J. A. LeClercC. E. Mangels
A. E. Treloar
R. M. Sandstedt

Committee on Standardization of Methods for Brewing and Malting Control

D. A. Coleman, Chairman
J. D. Veron
D. S. WilliamsH. C. Gore
Elsie Singruen

Committee on Standardization of Laboratory Baking

W. F. Geddes, Chairman
R. T. Bohn
C. N. Frey
M. J. Blish
G. MoenR. K. Larmour
E. B. Working
D. A. Coleman
T. R. Aitken

Committee on Methods of Testing Self-Rising Flours

H. G. Walter, Chairman
H. V. MossR. A. Barackman
F. A. Collatz

Committee on Testing Biscuit and Cracker Flours

R. M. Bohn, Chairman
Avery Dunn
G. F. Garnatz
E. L. UlreyPearl Brown
C. O. Oppen
Jan Micka

Committee on Cake Baking Tests

G. L. Alexander, Chairman
C. A. Glabau
H. F. Vaupel
J. R. DaviesW. E. Stokes
R. T. Bohn
H. D. Liggitt

Committee on Testing Pie Flours

C. B. Kress, Chairman
M. L. Schleifstein
C. G. HarrelW. K. Marshall
L. Bisno
P. O. Hastings

Committee on Testing Rye Flours

L. H. Bailey, Chairman
J. T. Flohil
T. W. SanfordG. Moen
W. G. Epstein
L. W. Haas

Committee on Definition of Moisture Basis for Laboratory Reports

R. K. Durham, Chairman
J. W. ChulowM. A. Gray
J. A. LeClerc

Committee on Definitions of Technical Terms

C. H. Bailey, Chairman
C. B. Morison
M. A. GrayQ. Landis
M. J. Blish

Committee on Employment

C. B. Morison, Chairman

M. D. Mize

C. H. Bailey

Publicity Committee

H. W. Putnam, Chairman

M. A. Gray

R. Frye

V. E. Marx

W. L. Haley

E. S. Stateler

History Committee

R. J. Clark, Chairman

Leslie R. Olsen

Committee on Osborne Medal Award

P. Logue, Chairman

A. H. Johnson

C. L. Alsberg

C. G. Ferrari

E. E. Smith

Paper—"The Growth of Pure Cultures of Bread Molds as Influenced by Acidity," by G. W. Kirby and C. N. Frey, read by G. W. Kirby.

Paper—"The Carotinoid Pigments of Wheat," by M. C. Markley and C. H. Bailey, read by M. C. Markley.

Paper—"A Study of the Carotene Content in the Flour and Whole Wheat of a Series of Rust Resistant Strains and Its Relation to Other Factors Affecting Quality," by C. H. Goulden, W. F. Geddes, and A. G. O. Whiteside, read by C. H. Goulden.

Paper—"The Influence of Environment on the Carotene Content of Hard Red Spring Wheat," by A. G. O. Whiteside and J. Edgar, read by A. G. O. Whiteside.

The members present gave a rising vote of thanks to A. E. Cliffe and the members of the Local Arrangements Committee and also a rising vote of thanks to M. J. Blish and the members of the Program Committee in appreciation of the excellent convention and program so thoroughly enjoyed by everyone.

Paper—"Investigation of a Mercury Vapor Lamp for Accelerating the Bleaching Action of Dibenzoyl Peroxide and also Quartz Electrode," by C. G. Ferrari and Alice B. Croze, read by C. H. Bailey.

Paper—"Solution of Carotinoid Pigments as a Standard in the Colorimetric Examination of Flour Color," by C. G. Ferrari and Alice B. Croze, read by C. H. Bailey.

Paper—"The Occurrence of Acetylmethylcarbinol in Bread and Its Relation to Bread Flavor," by F. Visser't Hooft and F. J. G. de Leeuw, read by F. Visser't Hooft.

"An Apparatus for Determination of Flour Particle Size," by M. C. Markley.

"An Apparatus; Modified Precision Manometer for Gassing Power Estimation," by Q. Landis.

"An Apparatus; Modified Proofing Cabinet," by H. W. Putnam, read by M. J. Blish.

Convention adjourned by President Mary M. Brooke.

REGISTRATION OF CONVENTION, TORONTO, CANADA

June 4-7, 1934

Members

T. R. Aitken
G. L. Alexander
W. G. Anderson
A. W. Alcock
John S. Andrews
Chas. C. Armuth
C. H. Bailey
L. H. Bailey
R. A. Barackman
E. G. Bayfield

Geo. C. Benson
M. J. Blish
Leonard J. Bohn
Ralph M. Bohn
R. T. Bohn
D. L. Boyer
Elliott Bredin
Mary M. Brooke
Pearl Brown
E. Douglas Brown

Harold J. Brownlee
W. E. Brownlee
Theodore E. Carl
A. E. Cliffe
D. A. Coleman
F. A. Collatz
J. R. Davies
F. L. Dunlap
R. K. Durham
J. A. Dunn

Wm. F. Farrell
C. C. Fifield
John T. Flohil
E. N. Frank
J. Freilich
Chas. N. Frey
Geo. Garnatz
W. F. Geddes
Chas. A. Glabau
W. E. Glasgow
M. A. Gray
N. L. Gregory
H. E. Guertin
C. B. Gustafson
L. W. Haas
Cleo Near Hanson
C. G. Harrel
R. H. Harris
A. E. Herron
Dr. F. Visser't Hooft
Geo. E. Howe
Bert D. Ingels
L. E. Jackson
A. H. Johnson
H. H. Johnson
Joseph H. Julicher
Jas S. Kelley
G. W. Kirby
E. J. Kiteley

Robt. M. Ladd
Quick Landis
R. K. Larmour
S. J. Lawellin
L. E. Leatherock
H. D. Liggitt, Jr.
Paul Logue
F. D. Machon
G. L. MacDonald
C. H. MacIntosh
C. E. Mangels
Max C. Markley
R. M. McKinstrie
D. A. MacTavish
W. G. McLeod
Victor E. Marx
P. E. Minton
C. B. Morison
Claude L. Moore
M. D. Mize
R. Wallace Mitchell
H. S. Mitchell
H. V. Moss
Clarence Oppen
Hugh K. Parker
Earl C. Paulsel
Washington Platt
R. A. Fouchain
Glenn L. Pyle

J. W. Read
Walter Reiman
O. H. Raschke
L. B. Reed
W. A. Richards
C. E. Rich
Perie Rumold
R. M. Sandstedt
R. C. Sherwood
Elsie Singruen
V. Shipley
A. A. Schaal
Edw. E. Smith
E. S. Stateler
J. D. Stone
W. E. Stokes
E. A. Vaupel
James D. Veron
Clarence C. Walker
H. G. Walter
T. R. West
H. K. Wilder
Stewart White
J. W. Whitacre
L. D. Whiting
D. S. Williams
Gordon Whiteside

Visitors and Guests

Mrs. Chas. C. Armuth
Mrs. S. A. Beath
Miss Georgia Bohn
Mrs. R. M. Bohn
Mrs. R. T. Bohn
Mrs. D. L. Boyer
Mrs. J. H. Brownlee
Mrs. Helen Cliffe
Mrs. Chas. Doyle
Mrs. Isabel J. Dunn
Mrs. E. Elder
Mrs. J. Freilich
Mrs. C. A. Glabau
Mrs. M. A. Gray
Miss Jean Gray
Mrs. N. L. Gregory
Mrs. C. B. Gustafson
Miss Jane Gustafson
Mrs. L. W. Haas
Mrs. Marguerite Herron
Mrs. Geo. E. Howe
Mrs. L. E. Jackson
Mrs. H. H. Johnson
Mrs. J. H. Julicher
Mrs. S. J. Lawellin

Mrs. L. E. Leatherock
Miss M. Leatherock
Mrs. H. D. Liggitt
Miss MacDonald
Mrs. C. H. MacIntosh
Mrs. D. A. MacTavish
Mrs. F. A. Madge
Mrs. E. Marx
Mrs. P. E. Minton
Mrs. R. Wallace Mitchell
Miss Edith Near
Mrs. Earl C. Paulsel
Mrs. Washington Plat
Mrs. R. A. Pouchain
Mrs. O. H. Raschke
Miss I. Richardson
Mrs. G. C. Robinson
Mrs. Perie Rumold
Mrs. R. C. Sherwood
Mrs. E. E. Smith
Miss Wilma Stewart
Mrs. Rita J. Stokes
Mrs. J. D. Stone
Mrs. E. A. Vaupel
Mrs. Jas. D. Veron

Mrs. E. Walker
Mrs. H. G. Walter
Mrs. T. R. West
Mrs. J. W. Whitacre
Harry G. Branilett
C. R. Cousins
F. J. G. DeLeeuw
Carl F. Evert
D. H. Farrar
M. S. Fine
Robt. S. Fish
C. H. Goulden
J. P. Henderson
C. B. Limbrick
J. G. Malloch
Floyd Nessler
A. Pitann
Richard P. Quance
J. J. Quittenton
B. U. Rasmussen
Chas. H. Reid
Guy C. Robinson
Neil H. Sherwood
H. Shipley
E. G. Wood

PRESIDENTIAL MESSAGE

R. C. SHERWOOD

General Mills, Inc., Minneapolis, Minnesota

(Read at the Annual Meeting, Toronto, June 4, 1934)

We are assembled for the Twentieth Annual Meeting of the American Association of Cereal Chemists: This is the first time we have met in Canada and it is indeed gratifying to see such a large attendance. The program prepared by the Program Committee this year is filled with original papers and reports of the investigational committees that should prove of interest to all members. It is our pleasure this year to have two joint sessions, Tuesday evening with the Canadian Chemical Association, and Thursday morning with the American Association of Operative Millers, and the Canadian and American Societies of Bakery Engineers. During the week's program we will be privileged to hear several guest speakers. These contacts are very valuable to cereal chemists.

The chairmen of the various sessions have been delegated with the responsibility of conducting the sessions on schedule. Efforts have been made to have the speakers confine their remarks to the allotted time in order to allow plenty of time for discussion, which is one of the most beneficial parts of the week's program. With everyone's cooperation I am sure that the program will go forward smoothly, and to the satisfaction of each member in attendance.

The suggestions made by members assembled at the annual meeting last year have been incorporated as far as possible. The differences of opinion, expressed last year, regarding the value of theoretical versus practical papers is sufficient evidence that the program committee each year should offer a balanced program. The large number of papers offered this year has presented a real problem for the program committee. The only apparent solution was to place limitations on the time for presentation. We are fast approaching the time when two sessions on different topics must be conducted concurrently, if we are to restrict our annual meeting to four days.

Substantial progress has been made during the past year along several lines. Each year the Association is rendering more service to its members, and it is apparent that the value of membership is recognized, as there has been no net loss of members during the past few years of depression. With general improvement in business conditions we can

look forward confidently to an increase in our membership and wider service to the chemical profession. Our interests are broadening, and we are attracting more and more chemists who are active in a variety of fields. This is a healthy sign and indicates to me that our Association has an opportunity to become a great force in other branches of food chemistry as well as in the chemistry of cereals.

The proceedings of the annual meeting, which were first published under R. K. Durham's administration, were again printed and distributed for the 1933 meeting, under the supervision of L. D. Whiting, and the meeting this year will be reported in the same manner.

For several years our History Committee, under Ralph W. Mitchell, has labored diligently in compiling a history of the early life of our Association. The manuscript has been completed to 1930 and publication has been approved by the Executive Committee. It will be financed with Association funds and the history will be mailed without charge to each member in good standing some time during the summer months.

Cereal Chemistry has completed its tenth volume and it continues to be the Association's best advertisement, and practically the only means for the individual members to keep up to date in our specialized field. Every effort should be made to continue the high standard set ten years ago. The editors and the editorial board should have the enthusiastic support of each member of the Association. Because of the increase in size of the Journal in recent years, subscription rates were raised January, 1934, from \$4 to \$5 per volume.

The value of Cereal Chemistry, as a reference, depends largely upon the facility with which the earlier issues can be reviewed. Believing that a decennial index will add greatly to the usefulness of the journal, plans have been made for publishing such an index. The editorial work is partly completed and it will be only a few weeks until the index is printed. After careful deliberation the Executive Committee has decided to appropriate funds from the reserve to defray the expense of printing and mailing.

Plans have been practically completed for publishing a revision of the Book of Methods, following two years work by the Methods Committee. Plans for publishing the book will be presented to this assembly in detail when the Methods Committee gives its report.

The report of Secretary-Treasurer Mize, published in the March issue, shows that the Association is in good financial condition. It has the largest balance in its history. Considerable responsibility for properly investing the reserve funds rests with the officers and especially with the Secretary-Treasurer. It has been suggested that a financial advisor be selected for consultation with the officers in order to insure

a sound, long time program. The Executive Committee is now considering this matter.

The formation of local sections of the A. A. C. C. was first recommended by Rowland J. Clark in 1926 when he was president. Sections have increased in number until there are now ten, and during this week we will officially welcome the eleventh section. A very important part in the expansion of the Association activities is being played by the sections. They have been a factor in developing closer cooperation between members of the Association, and their frequent meetings have stimulated interest in Association affairs. The officers of local sections are in excellent position to build for the Association, and it is largely through the local section activities that we will be able to increase our membership and our service to the profession.

It was because of my conviction that the sections are natural feeders for the national organization that the Membership Committee was composed the past year of section chairmen. Secretary Mize reports that 58 new members have been accepted since the last annual meeting. This is a net gain of 27. I believe that this plan of organizing the Membership Committee has proven successful and should be continued. Increase in membership should be one of our aims, but in our plans for expansion, let us not overlook the necessity of maintaining a high scientific standard.

I have heard the statement that our Association has more committees than any other association of its size in the world. Possibly this is true. We now have 15 standing committees. It is my opinion, however, that we are not over-organized in this respect. Many of our committees are functioning in a research or investigational capacity and a great deal of valuable experimental work is fostered by the Association in this way. Many of our members are thus stimulated to conduct researches that otherwise might not be undertaken. I will not attempt to review the accomplishments of committees in the past, but those who have followed Association affairs closely are fully aware of the valuable contributions made by our committees. A splendid spirit of cooperation has been shown by members in accepting committee duties, and the Association is greatly indebted to the chairmen of the committees, and the many members who have willingly given their time to this important work.

A new committee was recently appointed for the purpose of advising with officials of our Federal, State and Municipal departments, and with allied organizations, active in the food industries, respecting proposed legislation and proposed new standards for food products. This new Committee will have official standing as a representative of the

Association and thus our members will have an opportunity to take an active part in supplying technical information regarding food standards and food legislation.

During the period of its existence, the Association has accumulated an appreciable amount of physical equipment which is the property of the Association. The Managing Editor of Cereal Chemistry and the Secretary-Treasurer have been asked to file an annual inventory of this equipment in the Secretary's office, where this information will always be available.

Frequent discussion is heard regarding the selection of the annual meeting place. It is my recommendation that we continue our present plan of selecting the meeting place, and in the future select cities in different sections of the country. In my opinion it is inadvisable to select any city as a permanent meeting place. Since the last few meetings have been held in the middle west and east, it is highly desirable to select a city in the southwest or northwest for the next meeting place. It is recommended that the Executive Committee outline a plan for three years at a time in considering locations for the annual meetings.

Two years ago R. K. Durham recommended that election by mail be considered. The Executive Committee the following year decided not to make any recommendations to change our present system. It is my opinion that this matter deserves careful consideration again, and I have recommended that the Executive Committee draw up a plan for election by mail in advance of the annual meeting in order that all members will have an opportunity to vote. At present our officers are elected by votes of approximately one-fourth the total membership, which is too small a percentage.

The term of office of the officers of the Association does not coincide with the fiscal year. A few years ago the fiscal year of Cereal Chemistry and the Association was changed to coincide with the calendar year and the change has been found beneficial. I believe we should consider changing the term of office to the calendar year. If the officers were elected by mail ballot to take office on January 1, they would have an opportunity to plan a program for the Annual Meeting, submit their plan of action for approval to the members at the Annual Meeting, and continue in office long enough after this meeting to carry out their plans, publish the proceedings of the meeting and carry to completion any action recommended by the assembly in convention. Such a radical change should not be undertaken without careful deliberation, as there are both advantages and disadvantages, but it appears worthy of consideration in the future.

I wish to take this opportunity to express my sincere appreciation to the other officers of the Association, members of the Executive Committee, the committee chairmen, and all members who have taken an active part during the past year. I have found on every hand a desire to be helpful in Association affairs, and I am truly thankful for the cooperation of the members who have accepted the duties assigned to them. I wish to commend particularly the chairman of the Program Committee, Dr. Blish, and the chairman of the Local Arrangements Committee, Dr. Cliffe, both of whom have given unstintingly of their time to make this Annual Meeting an outstanding success.